REDDINGTON LEVEE SETBACK PROJECT

YEAR 1 MONITORING REPORT

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Monitoring Year 1 of 10

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Report Summary

Reddington Levee Setback Project Year 1 project effectiveness monitoring was completed in 2014. The main habitat-related objectives were to:

- Increase the area of low velocity and side channel habitat,
- Retain installed wood on site,
- Establish a native riparian buffer, and
- Increase juvenile salmonid use of the project area.

These habitat objectives were largely met. Low velocity edge habitat increased 190% to 1911% over pre-project conditions, depending on the flow. The side channel was connected 29% of the time between January 1 and June 30. Installed wood remained stable and some large wood was recruited to an excavated alcove area. Plant survival was variable, ranging from 58-89%. Invasive plant cover exceeded performance standards in two planting areas. Juvenile Chinook use of the project area was higher than nearby control sites representing pre-project conditions.

Adaptive management actions included replanting to meet plant survival performance targets, invasive plant species removal, additional rock removal to allow for continued erosion into the side channel area, and side channel inlet excavation to allow more frequent flow-through conditions.

Lessons learned include more attention and preparation to offset unfavorable conditions prior to planting, as well as planning ahead for the possibility of additional site adjustments following initial high flows.

I. Project Summary

Project Location

The project area extends from the southern boundary of Port of Seattle's wetland mitigation project at rivermile (RM) 28.2 (43rd Street Northeast) to RM 29.5 at Brannan Park (26th Street Northeast). The gravel access road extends from RM 28.2 to RM 28.6 and the levee setback (0.9 miles long) extends from the northern end of the River Mobile Estates (RM 28.6) to the southern end of Brannan Park (RM 29.5).

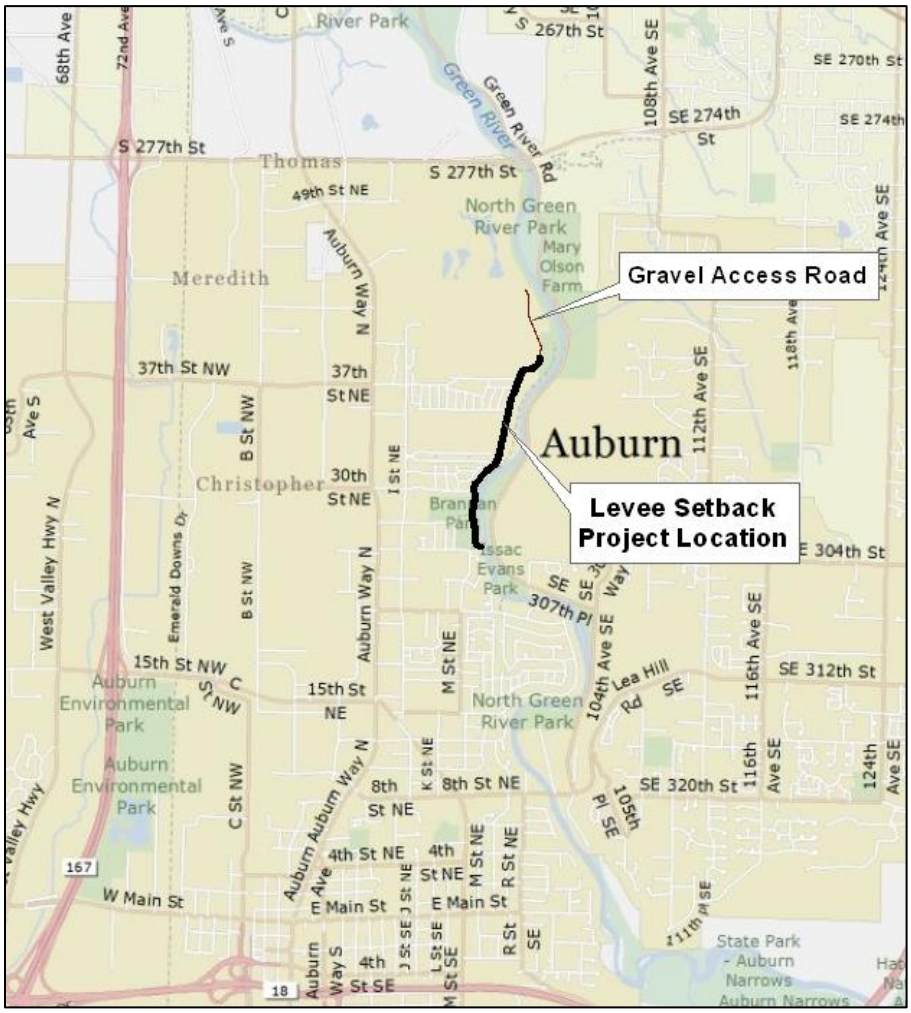

FIGURE 1. REDDINGTON LEVEE SETBACK VICINITY MAP

Project Justification

King County's *2006 Flood Hazard Management Plan* (King County 2007) proposed system-wide improvements to the county's aging system of levees and revetments, many of which no longer function as originally designed.

The 2006 Flood Plan identified the Reddington/Brannan Park area as follows:

> *"The Reddington Levee here follows an old road alignment and cuts off older meander scrolls, one of which has been developed as a trailer park within the mapped floodplain of*

the Green River. These older meanders are connected to the river with a poorly constructed culvert through the levee, fitted with a small flap-gate. Flooding of the trailer park still occurs, when this system fails to properly close during flood events. Just upstream of these meanders, a newer culvert outfall with a flap-gate and backup closure system have recently been constructed to serve new developments and a future regional stormwater system planned by Auburn. The lower end of the Reddington Levee is constructed at steep slope angles with rip-rap armor, and supports very little vegetation other than blackberries and canary grass. Central portions of this segment are set well back from the riverbank, and pass through a mature deciduous riparian grove of cottonwoods and other trees and shrubs. The Brannan Park portions of this reach include very steep rip-rap armored portions that encroach closely on the channel, together with a minor, vegetated meander bar near the upstream end. The levee borders an Auburn park with ball fields, a sewage pump lift station, and a regional biofiltration swale with a concrete imbedded rip-rap outfall through the levee. Toe structure is questionable in all rip-rap slope portions along the channel edge. Two feet of freeboard is likely present throughout, with landward areas, especially at Brannan Park, located about 6 to 8 feet in elevation below the levee crest."

The 2006 Flood Plan identified the following project to address the flood risks and habitat restoration opportunities at the Reddington Levee:

> *"Remove and reconstruct the Reddington Levee in a setback location adjacent to the mobile home park, along the landward edge of the old side channel area. Reconnect the old side-channel habitat to the main stem. Reduce the flooding of mobile homes due to the existing malfunctioning flap-gate/culvert system, and install a new, robust flood closure system with a backup closure device. Stabilize the channel edge and restore aquatic habitat complexity with large woody debris installations, and revegetate both the new levee slopes and the former levee footprint area with native riparian trees and shrubs."*

The Green River basin is identified under Washington State's water resource planning program as the Green/Duwamish and Central Puget Sound Watershed, or Water Resource Inventory Area (WRIA) 9. The WRIA 9 Salmon Habitat Plan (WRIA 9, 2005) identifies categories of actions for the recovery of endangered salmon in the Green River, along with specific project recommendations. The plan presents policy statements that are pertinent to the Reddington Levee setback project, including the following:

- Policy LG1—In the Lower Green River, every opportunity should be taken to set back levees and revetments to the maximum extent practicable. Habitat rehabilitation within the Lower Green River corridor should be included in all new developments and re-developments that occur within 200 feet of the river.

One of the projects listed in the Salmon Habitat Plan is within the Reddington Levee setback project area. It is identified as Project LG-1, and it calls for side channel rehabilitation on the left bank of the Green River at RM 28.8 (the River Mobile Estates). This project is also identified as a priority for habitat restoration in the Green/Duwamish Ecosystem Restoration Project (ERP) Plan.

Habitat Goals and Objectives

The habitat restoration goal and associated objectives of the Reddington Levee Setback Project are as follows:

Improve natural river functions to enhance habitat by:

- Setting back levees to allow for more channel movement within the project area,
- Allowing the river to meander, scour and develop more complex instream and riparian habitat, which includes enhanced juvenile salmonid rearing habitat,
- Providing flood refuge for fish by decreasing water velocities within a corridor of newly restored riparian forest in an area that currently is occupied by the existing Reddington Levee,
- Adding large wood to improve habitat complexity and enhance juvenile rearing habitat, and
- Acquiring land that will allow not only the levee setback, but also permanent protection of existing and newly planted vegetation that over time will increase shoreline and channel shading, support the riparian food web, and improve fish and wildlife habitat adjacent to and within the river channel.

Project Actions

The following actions were implemented to achieve the above-stated habitat objectives, as well as meet flood risk reduction objectives for the King County Flood Control District (Figure 2):

- Removal of approximately 4,700 linear feet (LF) of existing levee prism and rock revetment (RM 28.6-29.5),
- Construction of approximately 4,800 LF of setback levee (RM 28.6 to 29.5, from the north end of River Mobile Estates south to 26th Street NE); a gravel construction and maintenance access road to connect the north end of the levee to R Street,
- Construction of nine buried rock barbs (landward of the existing river channel) to deflect erosive flows away from the toe of the setback levee and encourage formation of floodplain alcoves and riparian forest,
- Installation of approximately 122 key pieces of large wood between the rock barbs; the log jams in the three excavated alcoves also include 54 pieces of racking wood and additional slash,
- Reconnection of Wetland E with the active river channel. This wetland was historically part of the active river channel. Levee removal and notching allow riverine flow-through hydrology to the wetland, thereby restoring natural wetland and riverine conditions,
- Construction of eight ELJs (a total of 112 key pieces and 112 pieces of racking wood) in Wetland E designed to roughen the channel edge and provide salmonid rearing and refuge habitat,
- Excavation of three shallow alcoves between Barbs 6-9 to provide juvenile salmonid rearing and refuge habitat as well as to create at least 0.44 acres of wetland (side channel inlet and outlet excavation may also create some wetland areas),
- Revegetation and enhancement of approximately 19 acres of riparian and wetland buffer on the left and right banks. The planting includes approximately 4,200 trees, 7,000 shrubs, and 9,000 willow stakes (stake count includes willow lifts in left bank revetments),
- Acquisition and demolition of residential structures to maximize the restored river corridor provided by the levee setback, and
- Utility construction and relocation.

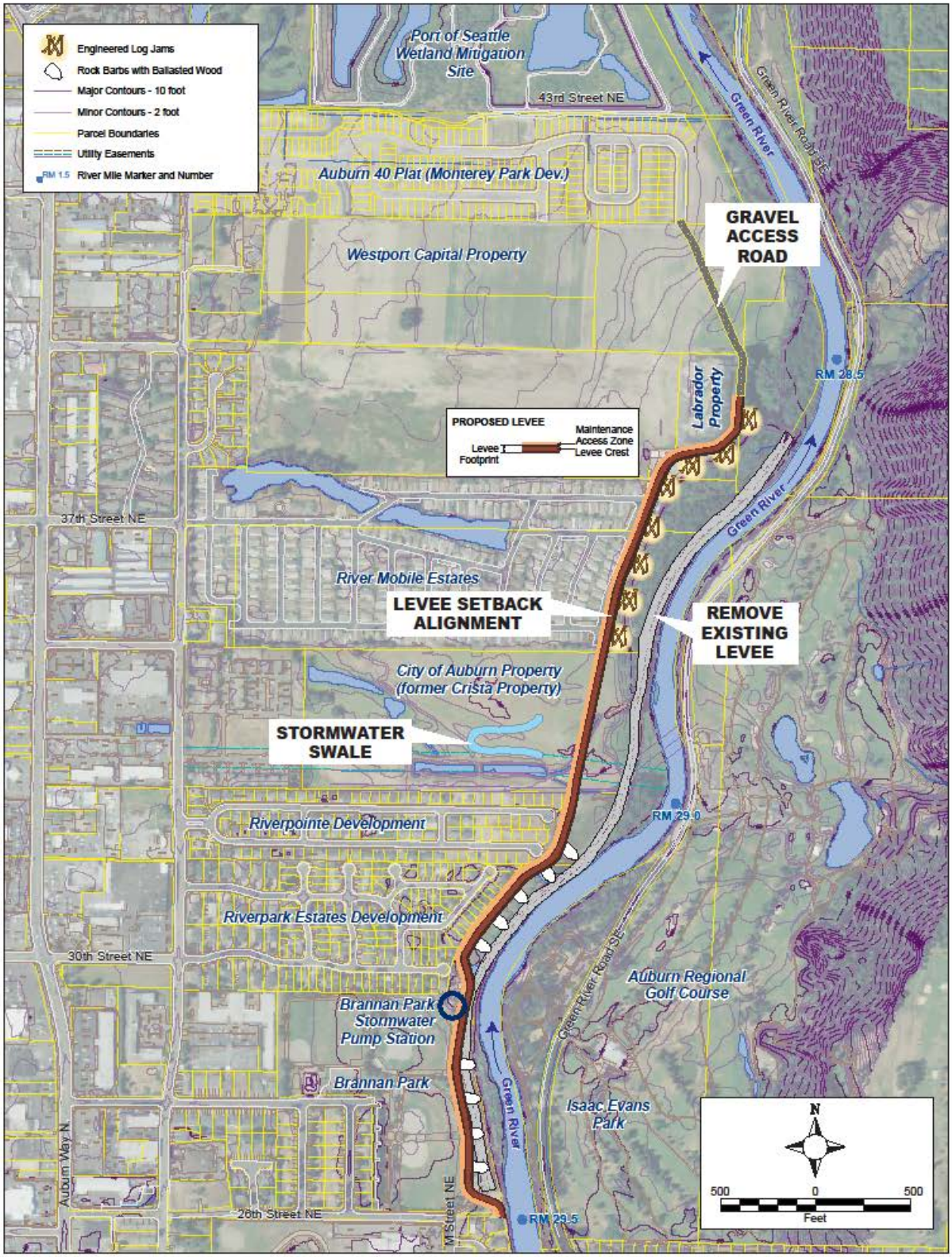

FIGURE 2. REDDINGTON LEVEE SETBACK PROJECT ELEMENTS

Performance Standards

Monitoring objectives and performance standards are designed to determine project effectiveness (Table 1).

TABLE 1. PERFORMANCE STANDARDS ESTABLISHED BY THE DESIGN TEAM AND AGENCY PERMITS.

Category	Indicator	Objective	Performance Standards	Adaptive Management
Project Implementation	As-built condition	Project is constructed according to design specifications.	As built condition satisfies design objectives.	N/A; adjustments to meet design specifications made during construction.
Habitat Benefit	Aquatic habitat	The area of slow-water edge habitat will increase.	Increased area <1.5 ft/sec at average daily discharge during Chinook rearing (~1800 cfs).	Project objective not met.
		The side channel at the RME wetland will provide Chinook rearing habitat.	Flow through the side channel at least 25% of the time during Jan-Jun.	Large wood placement or excavation may be considered.
	Placed wood	Engineered log jams and ballasted logs resist significant lateral displacement.	The key pieces are stable and remain within the project segment.	Reposition/reanchor wood as necessary for public safety or habitat benefit.
	Riparian cover	Installed plants survive.	80% survival[1] at end of Year 1 growing season for all installed trees and shrubs (excluding stakes) in Planting Zones A, C, D, E, F, G, and H.	Additional planting or maintenance needed.
			80% survival[1] in Years 1 through 5 for all installed trees in Planting Zones I, J, K, and L (right bank).	Additional planting or maintenance needed.
		Installed plants, as well as volunteers of desirable native woody species, form a healthy canopy cover.	Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species, in Planting Zones A, C, D, E, G (excluding willow-planted areas), and H: Year 2 at least 15%, Year 3 at least 20%, Year 5 at least 40%, Year 7 at least 60%, and Year 10 at least 75%.	Additional planting or maintenance needed.
			Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species, in Planting Zones F and the wetted area of Zone G: Year 2 at least 15%, Year 3 at least 25%, Year 5 at least 50%, Year 7 at least 70%, and Year 10 at least 80%.	Additional planting or maintenance needed.
			Cover by installed cottonwood stakes, including cover by volunteers of desirable native woody species, in Planting Zone B: Year 2 at least 5%, Year 3 at least 10%, Year 5 at least 25%, Year 7 at least 40%, and Year 10 at least 50%.	Performance standards may need to be altered in the future due to expected channel movement in this area.
		Rock barbs allow a vegetated riparian buffer to form between river and setback levee.	Average vegetated riparian buffer width of 30 feet in Planting Zones G and H.	Additional planting may be warranted; reconsider design approach in similar settings.
	Invasive cover	Invasive plant cover is minimized due to native revegetation.	Less than 10% invasive cover in planted areas (0% for KC Class A noxious weeds, bindweed, and knotweed).	Additional maintenance needed.
	Wetlands	Wetland characteristics are evident in excavated areas.	At least 0.44 acres of riverine wetland created.	To be determined depending on conditions.
		Wetland area temporarily impacted by construction is restored.	0.51 acres temporarily impacted in Wetland E restored as Waters of the US (wetland habitat condition or stream side channel).	To be determined depending on conditions.

[1]Only installed plants count towards achieving the Survival Performance Standard; volunteers do not count.

II. Monitoring Strategy

Monitoring Purpose

An understanding of natural floodplain processes and baseline conditions is essential for planning river and floodplain restoration projects and for evaluating effectiveness (Ward et al. 2001, Pess et al. 2005). Because the science of floodplain restoration is still in development, restoration actions should be viewed as experimental manipulations linked to explicit hypotheses (Pess et al. 2005). The purpose of this monitoring effort is to evaluate whether a large-scale levee setback project on the lower Green River effectively meets the stated project goals and objectives and is able to test the monitoring hypotheses.

The purpose of this habitat monitoring effort is to:

1. Ensure the project satisfies habitat design objectives (Implementation Monitoring),
2. Determine whether levee setback project actions are producing the intended habitat effects on floodplain reconnection, wetland creation, and aquatic habitat conditions (Effectiveness Monitoring), and
3. Improve habitat design, construction, and maintenance practices using monitoring results (Adaptive Management).

Audience

The primary audiences for implementation and effectiveness monitoring results include:

1. King County staff – Results will be shared to inform future project design, construction, and monitoring protocols, as well as project maintenance needs. The reporting format includes presentations, monitoring reports, and access to real-time data.
2. Regulatory agencies – Monitoring results will allow regulatory agencies to determine whether performance standards are being met, as well as inform review of future projects with similar elements. Monitoring reports will be submitted to the US Army Corps of Engineers and Washington Department of Fish and Wildlife in Years 1, 2, 3, 4, 5, 7, and 10.
3. Key stakeholders – The results of this study will be shared with project stakeholders including the Muckleshoot Indian Tribe, the Water Resource Inventory Area (WRIA) 9 Forum, and the City of Auburn. The reporting format includes presentations and monitoring reports.
4. Scientific community – This study will add to a growing body of research into the effects of large-scale levee setback projects on channel processes and habitat conditions, as well as the efficacy of levee setbacks for flood risk reduction in managed rivers.

Monitoring Design

Specific indicators (slow water edge habitat, bathymetry, and wetlands) were monitored before and after project implementation to measure changes in physical and biological process as well as to assess the ability of the project to meet its stated objectives. Control sites were used for fish monitoring to account for variability related to environmental fluctuations, and because fish data were not collected before project implementation. Plant survival and cover and wood stability and recruitment were only monitored after project implementation.

Monitoring Tasks and Objectives

This section explains the specific steps that are being followed to measure performance indicators (Table 2).

TABLE 2. MONITORING OBJECTIVES, METHODS, AND OUTPUTS

Category	Indicator	Performance Standard	Task	Monitoring Method	Timing (Years)	Output
Project Implementation	As-built condition	As built condition satisfies design objectives.	1	Manage construction to ensure project satisfies design objectives; Produce record drawings.	Immediately post-construction	Record drawings
Habitat Benefit	Aquatic habitat	Increased area <1.5 ft/sec at average daily discharge during Chinook rearing (~1800 cfs).	2	Map slow water areas on channel margins at flows representing 50th, 75, and 90th percentile flows during Jan-Jun	1, 5, 10	Change in edge habitat area relative to baseline
		Flow through the side channel at least 25% of the time during Jan-Jun.	3	Document side channel flow conditions during Jan-Jun rearing period using time lapse photography.	1, 3, 5, 7, 10	% of days side channel connected to mainstem
	Placed wood	The key pieces are stable and remain within the project segment.	4	Document stability	1, 5, 10; following Phase III floods	Visual assessment of change
	Riparian cover	80% survival at end of Year 1 growing season for all installed trees and shrubs (excluding stakes) in Planting Zones A, C, D, E, F, G, and H.	5	Fixed plots	1	Percent survival of installed plants
		80% survival in Years 1 through 5 for all installed trees in Planting Zones I, J, K, and L (right bank).	6	Plant tallies	1, 2, 3, 4, 5	Percent survival of all installed plants
		Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species, in Planting Zones A, C, D, E, G (excluding willow-planted areas), and H: Year 2 at least 15%, Year 3 at least 20%, Year 5 at least 40%, Year 7 at least 60%, and Year 10 at least 75%.	7	Fixed plots[1]	1, 2, 3, 4, 5, 7, 10	Percent cover of native installed and volunteer woody vegetation (trees and shrubs)
		Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species, in Planting Zones F and the wetted area of Zone G: Year 2 at least 15%, Year 3 at least 25%, Year 5 at least 50%, Year 7 at least 70%, and Year 10 at least 80%.		See Task 7	1, 2, 3, 4, 5, 7, 10	Percent cover of native installed and volunteer woody vegetation (trees and shrubs)
		Cover by installed cottonwood stakes, including cover by volunteers of desirable native woody species, in Planting Zone B: Year 2 at least 5%, Year 3 at least 10%, Year 5 at least 25%, Year 7 at least 40%, and Year 10 at least 50%.		See Task 7	1, 2, 3, 4, 5, 7, 10	Percent cover of native installed and volunteer woody vegetation (trees and shrubs)
		Average vegetated riparian buffer width of 30 feet in Planting Zones G and H.	8	Use ground survey and digital airphotos to measure buffer width at fixed cross-sections	1, 5, 10	Minimum, average, and maximum buffer width.
	Invasive cover	Less than 10% invasive cover in planted areas (0% for KC Class A noxious weeds, bindweed, and knotweed).		See Task 7. Use fixed plots to measure percent cover of invasive plants. Survey entire area for invasive vegetation.	1, 2, 3, 4, 5, 7, 10	Percent cover of invasive plants
	Wetlands	At least 0.44 acres of riverine wetland created.	9	Wetland delineation at Year 5	5	Area of created wetland; Wetland delineation report
		0.51 acres temporarily impacted in Wetland E restored as Waters of the US (wetland habitat condition or stream side channel).		See Task 9. Document soils, vegetation, and hydrology in areas of temporary wetland impact.	5	Wetland delineation report

[1]Make observations of general site and habitat conditions as well as fish and wildlife use of the project site on datasheets.

Monitoring Schedule

All indicators were sampled at the project site (Table 3).

TABLE 3. MONITORING SCHEDULE

Task	Objectives	Pre-Construction	Post-Construction Baseline	Year 1 2014	Year 2 2015	Year 3 2016	Year 4 2017	Year 5 2018	Year 7 2020	Year 10 2023
1	Record drawings		X							
2	Edge habitat	X		X				X		X
3	Side channel connectivity			X		X		X	X	X
4	Log stability*			X				X		X
5	Plant survival in plots			X	X	X	X	X	X	X
6	Total plant survival (right bank)			X	X	X	X	X		
7	Percent vegetative cover			X	X	X	X	X	X	X
8	Vegetated buffer width			X				X		X
9	Wetland delineation	X						X		

*Additional sampling following Phase III flood events

III. Monitoring Methods

Project Implementation Monitoring Protocols

Upon completion of the project, the design drawings were updated to become record drawings. The record drawings are housed with King County's River and Floodplain Management Section. As-built planting sheets are included in this monitoring report as Appendix A.

Monitoring Protocols for Habitat Benefit Indicators

General Site Conditions

Surveyors noted general site and habitat conditions on field datasheets, including observed fish and wildlife use (direct observation of live or dead animals or indirect observation of prints, scat, etc.), general patterns of vegetation condition, invasive vegetation, illegal use or dumping, deformation or damage (movement of installed wood, bank erosion, etc.), and anything else considered worth noting.

Aquatic Habitat

Low Velocity Edge Habitat

Juvenile salmonids rely heavily on shallow relatively slow moving waters (Bjornn and Reiser 1991), therefore our analysis focused on surveying the availability of this critical habitat type in the project reach. The margin of the wetted channel was mapped on foot by GPS (<20cm accuracy). The midstream (waterward) margin of the low velocity edge habitat was located with a Swoffer flow meter (where water velocity was approximately <0.45m/sec) and the slow-water boundary was mapped at multiple points using a Trimble GeoXH GPS. Points and water margins were transferred to a GIS and the area, number, and distribution of low-velocity edges were quantified for each habitat type.

While low flow habitat may be present along the entire bank of the river, it was only mapped if the habitat unit area was greater than the stated accuracy of the GPS. Anything smaller than this could not

be accurately mapped and likely provided very little habitat value. Accuracy was generally less than 20cm, though depending on canopy cover generally ranged from 3 to 50 cm. Surveying was done during leaf off with clear conditions for optimal precision and accuracy, and data recording was paused if GPS reception was not reliable. Much of the right bank throughout the project reach could not be mapped due to the inability to access the shoreline (hazardous conditions and/or extremely thick blackberries), though it appeared little edge habitat was present.

Areas and types of edge habitat were calculated for each date for both pre and post construction. This data was then compared to discharge data to allow us to see changes in available edge habitat for pre and post restoration and various flows. While not a statistical test, this allows us to visually interpret changes in edge habitat after construction with various flows. Discharge was obtained from realtime data from USGS gauge 12113000 on the Green River near Auburn, WA.

The surveys were repeated in exactly the same way at three flow levels (+/- 5%), corresponding to the 50th, 75th, and 90th percentile flows during the January – June Chinook rearing period (however, the 75th percentile flow was not captured during baseline monitoring in 2013) (Table 4). In some cases, the range was increased to +/- 10% to facilitate data collection. Flow levels were classified according to USGS conventions; daily flows between the 25th and 75th percentile were considered 'normal', and flows greater than the 75th percentile were considered 'above normal'.

- 'Normal' or median: 1440 cfs (1368-1512)
- 'Above normal': 2110 cfs (2005-2216)
- 'High': 3150 cfs (2993-3308)

TABLE 4. LOW FLOW HABITAT SAMPLING EVENTS

Project timeline	Date	Discharge (cfs)
Baseline	4/30/2013	3060
Baseline	5/29/2013	1330
Post Construction	2/11/2014	1300
Post Construction	2/20/2014	3360
Post Construction	2/24/2014	2060

Side Channel Connection

The side channel adjacent to the River Mobile Estates was monitored using mounted game cameras, and set to take photos one time per day during the January to June Chinook salmon rearing period. The cameras were mounted at the upstream inlet and the downstream outlet to allow for analysis of flow-through conditions. The downstream (outlet) camera was vandalized and stolen sometime between May 8 and June 30, 2014, but sufficient data were collected to create a flow:connection relationship and therefore predict side channel connection during the last two months of the monitoring period in 2014.

Side channel inlet and outlet connection was noted if continuous standing or flowing water could be observed in the photo. The number of connected days was divided by the total number of days the side channel was monitored.

Placed Wood

Installed log structures were inspected for stability. Non-ballasted wood (i.e., wood placed in the floodplain and wood recruited following project implementation) was described using an alphanumeric code (Montgomery 2008; Table 5). Potential key pieces were classified as E4 or larger. The physical function of jams and pieces were noted as: pool scour, bar formation, bank stabilization, flow splitting, meander geometry, and sediment trapping. The ecological functions were noted as vegetation regeneration, juvenile salmonid cover, juvenile salmonid rearing habitat, and adult holding habitat.

TABLE 5. LENGTH AND DIAMETER CLASSES FOR LARGE WOOD CLASSIFICATION (FROM MONTGOMERY 2008)

	Diameter Class (m)					
Length Class (m)	**0.1-0.2**	**0.2-0.4**	**0.4-0.8**	**0.8-1.6**	**1.6-3.2**	**>3.2**
1-2	B2	B3	B4	B5	B6	B7
2-4	C2	C3	C4	C5	C6	C7
4-8	D2	D3	D4	D5	D6	D7
8-16	E2	E3	E4	E5	E6	E7
16-32	F2	F3	F4	F5	F6	F7
>32	G2	G3	G4	G5	G6	G7

Plant Performance and Invasive Cover

Vegetation monitoring transects were established in each left bank planting zone to evaluate plant survival, native plant cover, and invasive plant cover (see Appendix A). Transect locations were established randomly in the office to reduce bias in the field. In some cases, transect locations were modified slightly in the field to stay within a planting zone. Transects did not cross planting zones. A photo monitoring point was established at the beginning and end of each transect looking along the transect (Appendix B). The beginning and end of each transect was permanently established using a stake and recorded using GPS.

Plant Survival

Plant survival was measured in the left bank Planting Zones A, C, D, E, F, G, and H at the end of the growing season (between August 25 and September 23) slightly less than one year after installation (Year 1). Surveyors walked along the transects (tape stretched between the stakes), recording all installed plants within a 2-m rectangular band centered on the transect. Surveyors noted the species and whether the plant was alive or dead. Survival was not recorded for stake plantings. The entire planting area was scanned for areas of higher than average die-off. These areas were noted for replacement planting to meet the 80% survival performance standard.

Installed plants in Planting Zones I, J, K, and L (right bank plantings) were counted to estimate survival.

Native Vegetation Cover

Percent cover of installed trees and shrubs, including cover by volunteers of desirable native woody species, was measured along the permanent transects in the left bank Planting Zones A, C, D, E, F, G, and H in Year 1. Monitoring occurred in the end of the growing season (between August 25 and September

23). Significant rains began on September 25. Because the cottonwood stakes were removed for construction access along the lowered levee (Planting Area B), transects were not set in this area in 2014.

Five circular 3-m^2 monitoring plots were located along each 50-m transect at the 0, 10, 20, 30, and 40-m marks. All native woody and invasive plant species were noted. Remaining vegetation was grouped into "grass" and "common weed" categories. Each species or vegetative category was placed into a Daubenmire cover class (Daubenmire 1959).

Percent cover for each plot was analyzed using the median of each Daubenmire cover-class category and averaged to determine percent cover within each transect and planting area (Table 6).

TABLE 6. COVER CATEGORIES AND ASSOCIATED COVER CLASS IDENTIFICATION NUMBERS USED IN THE REDDINGTON VEGETATION COVER SURVEYS (DAUBENMIRE 1959)

Estimated Cover Category	Mid-Point	Cover Class
0-5%	2.5	1
5-25%	15	2
25-50%	37.5	3
50-75%	62.5	4
75-95%	85	5
95-100%	97.5	6

Invasive Species

Percent cover of invasive plant species was measured along the left bank transects (Planting Zones A, C, D, E, F, G, and H) in Year 1 following methods noted above. In addition, general surveys for invasive species occurred during regular monitoring and site inspections. Infestations of invasive species were noted for removal.

Regeneration

Due to construction-related disturbance in 2014, tree and invasive species regeneration was not measured in Planting Zone B in 2014. This will be conducted in Year 2.

Riparian Buffer Width

Aerial pictometry was not yet available to analyze riparian buffer width. This will be done in Years 2, 5, and 10 instead of Years 1, 5, and 10.

Plant Recruitment Study

The recruitment rate of native woody plant species was measured in the unplanted portion of Planting Area A. Four treatments (Control, Weed, Water, and Weed + Water) with 10 replicates each were sampled for percent cover of weeds and native plants, and recruitment rate of woody seedlings (see Reddington Monitoring Plan Addendum for further details). Data collection occurred on October 1, 2014.

Irrigation Study

Three irrigation treatments were used in Planting Area C to determine the efficacy of different techniques. Thirty-six plots 15 foot by 20 foot plots were established and planted with 10 each snowberry and red twig dogwood. Each of three treatments (hand water, drip irrigate, and no water) were used on twelve of the plots. Irrigation costs for each treatment were also tracked. Plant survival data were collected on October 7, 2014.

Fish Use

Although no performance standards were developed for fish use of the project site, fish were sampled in 4 representative locations along the project extent as well as 3 control and 3 reference sites outside the project reach (Table 7). Control and Reference sites were sampled under the Retrospective project, but could easily be compared to Reddington data because the same sampling procedures were used. These control and reference sites are used in this analysis to help us understand what nearby existing conditions and pre project conditions may be like in terms of fish use. A separate reference site is included from the Riverview side channel to assess this restoration habitat type on the Green river, since the Reddington side channel was disconnected or functioning as a backwater during our sampling window.

TABLE 7. FISH SAMPLING SITES

Site #	Site Type	Condition	Description
64	Reddington	Constructed	Outlet of the side channel
65	Reddington	Constructed	In the downstream excavated alcove
66	Reddington	Constructed	In between barbs 5 and 6
67	Reddington	Constructed	Rock bench along revetment
56	Control	Riprap	Steep bank with grass and trees
59	Control	Riprap	Steep bank with some willow
62	Control	Riprap	Steep bank with blackberry
57	Reference	Natural	Steep bank with roots and large alders
60	Reference	Natural	Steep bank with blackberry and willow
63	Reference	Natural	Sandy bank, almost eddy
71	Reference	Natural	Moderately sloping sandy bank with grass

Fish sampling took place at night during several discrete sampling events in Spring 2014 (Table 8). Surveys were conducted at night using a Smith-Root LR-24 backpack electrofishing unit mounted on a 14 foot Aire Ocelot cataraft. Equipment was maintained and provided by R2 resource consultants, and fish sampling was completed by a team of two R2 biologists and one King County biologist. For most sites the unit was set for 420 volts, 30Hz and 15% duty cycle and provided good fish capture while minimizing (or eliminating) fish injury and mortality. Sites with higher than average conductivity (i.e., side channels and tributaries) had the voltage adjusted down as needed. The National Marine Fisheries Service electrofishing protocol was followed during all backpack electrofishing surveys (NMFS 2000). In general as the river flow receded over the study period and velocities dropped samplers were able to shock areas further up under the overhanging vegetation (i.e., willow) cover and inward towards the banks. In

situations with placed wood the area between the logs and the bank was sampled, as the area outside the logs was generally too fast and/or deep to sample effectively. If necessary, the sites were sampled on foot with the backpack shocker.

TABLE 8. 2014 FISH SAMPLING DATES

Site #	Site Type	7-Apr	8-Apr	21-Apr	22-Apr	6-May	19-May	22-May
64	Reddington	X		X			X	
65	Reddington	X		X			X	
66	Reddington	X		X			X	
67	Reddington	X		X			X	
56	Control			X		X	X	
59	Control			X		X	X	
62	Control			X		X	X	
57	Reference			X		X	X	
60	Reference			X		X	X	
63	Reference			X		X	X	
71	Reference		X		X			X
Discharge (cfs)		*2,460*	*2,680*	*2,420*	*2,250*	*2,240*	*1,520*	*1,170*

Fish that were shocked were immediately removed from the electrical field with a nylon knotless dipnet. Captured fish were placed in a half-full bucket of water dosed with a small amount (<50mg/L) of MS-222 (Tricaine Methanesulfonate) in order to mildly sedate them. All fish were identified to species and measured to the nearest millimeter (fork length), with a subset of salmonids weighed to the nearest gram. In some cases a group of small fry were weighed together and an average weight was taken for them all. All fish marked with adipose or other fin clips were noted as such on the data sheets. After processing, the fish were placed in a recovery bucket of fresh water until completely revived, then released back to the ambient water near their point of capture.

Catch per unit effort (CPUE) was calculated by dividing the number of fish captured at each site by the amount of time in minutes spent actively electrofishing. CPUE was chosen as our sampling and analysis method for several reasons. First, CPUE is a semi quantitative method that requires much less time and fewer personnel to complete (Crozier and Kennedy 1994). Next, CPUE is less intensive, which allows us to operate within the take as listed under our scientific collection permit, while still allowing for representative sampling between all sites. Also, CPUE was chosen because river environments are difficult to sample, which in turn would make quantitative abundance estimates for many sites extremely difficult. Snorkeling was not used because water clarity in the Green river at this time of year is not conducive to accurate snorkel counts.

Statistical analysis was performed using SigmaPlot version 12.5 (Systat Software Inc San Jose California USA). CPUE was first tested for normality then tested using a one way repeated measures ANOVA test as described by Hubert and Fabrizio (2007), or a ranked repeated measures ANOVA if data was non-

parametric. If the test detected a significant difference between Reddington, Control, or Reference CPUE values, then a pairwise comparison was performed for each to determine which group(s) were significantly different ($P < 0.05$).

IV. Results

Project Implementation

Following survey and completion of record drawings, it was noted that the inlet to the side channel (Wetland E) was higher than designed. Accordingly, a lower flow inlet was excavated in 2014 to allow for more frequent inundation.

Habitat Benefit

General Site Conditions

The right bank (Planting Area I) was noted to have significant regrowth of Himalayan blackberry and Reed canarygrass, and some field bindweed. This area was identified for priority weed removal in August 2014.The blackberry is also growing in around the tree plantings in the buffer area of Planting Areas J and K.

During nighttime fish surveys in Spring 2014, surveyors noted American bullfrog use of Wetland E. More frequent inundation of this wetland beginning in Fall 2014 (as a result of the additional excavation at the inlet) may reduce bullfrog use of the wetland.

Planting crews have noted that large wood placed in the floodplain (not included in the original design plans) is being cut by members of the public. There has been no observed vandalism of the engineered log structures.

Aquatic Habitat

Low Velocity Edge Habitat

Prior to construction, baseline edge mapping resulted in a total of 5462 and 11368.5 square feet of low flow edge habitat at 1330 and 3060 cfs discharge, respectively. After construction, low flow edge habitat increased to 19860 square feet at 1300 cfs, 168547 at 2060 cfs, and 228617 at 3360 cfs (Figure 3). Total edge habitat changed with discharge, therefore to accurately compare pre and post project conditions we can only compare data from similar discharges. The relationship between discharge and low velocity edge habitat shows us that after construction, there was a greater increase in edge habitat with a corresponding increase in discharge compared to pre-construction (Figure 4). This is likely due to a more open floodplain post-construction, which allowed more area for low flow habitat to be engaged as water elevation increased. Prior to construction, steep banks at the project site likely limited the expansion of water into the floodplain therefore opening more edge habitat.

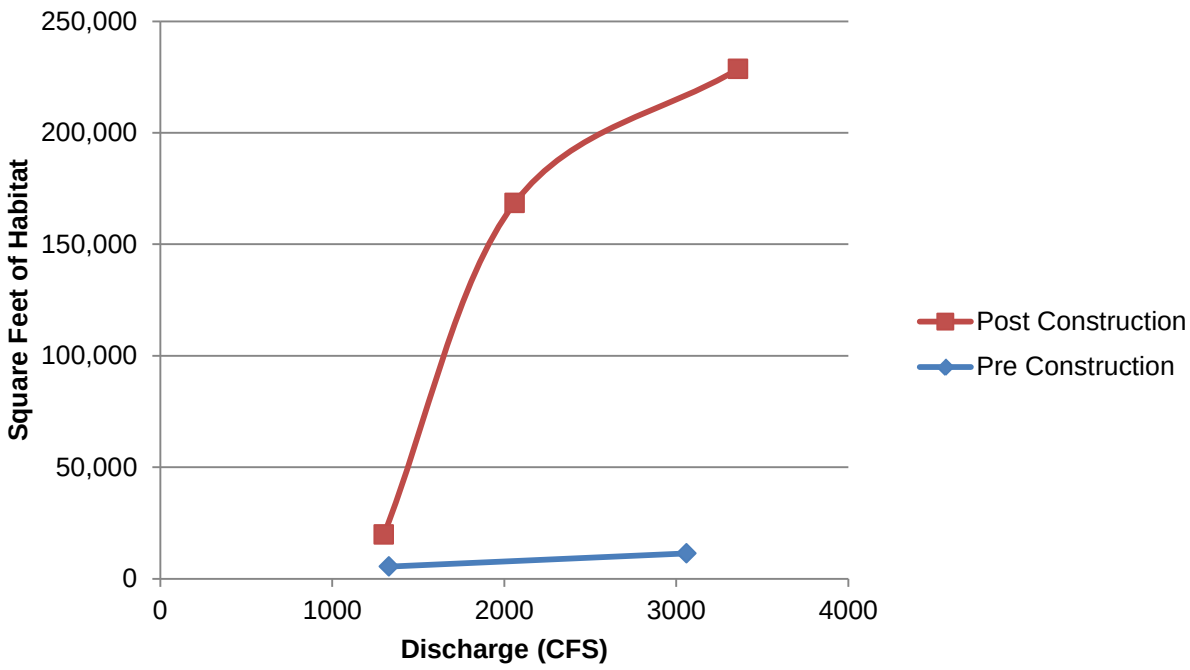

FIGURE 3. TOTAL LOW FLOW EDGE HABITAT BEFORE AND AFTER CONSTRUCTION.

Increases in edge habitat post construction were due in large part to the addition of the side channel at the lower end of the project. The side channel represented 2% of the total edge habitat at 1300 cfs, 79% at 2060 cfs, and 86% at 3360 cfs. The reason for the small contribution at 1300 cfs is because at this flow the side channel was not connected to the river, however the additional notch dug at the upstream entrance to the side channel after our surveys will increase the presence and availability of side channel habitat at lower flows. Figures 5 and 6 show area of mapped low flow habitat over the 50th, 75th, and 90th percentile flows post construction.

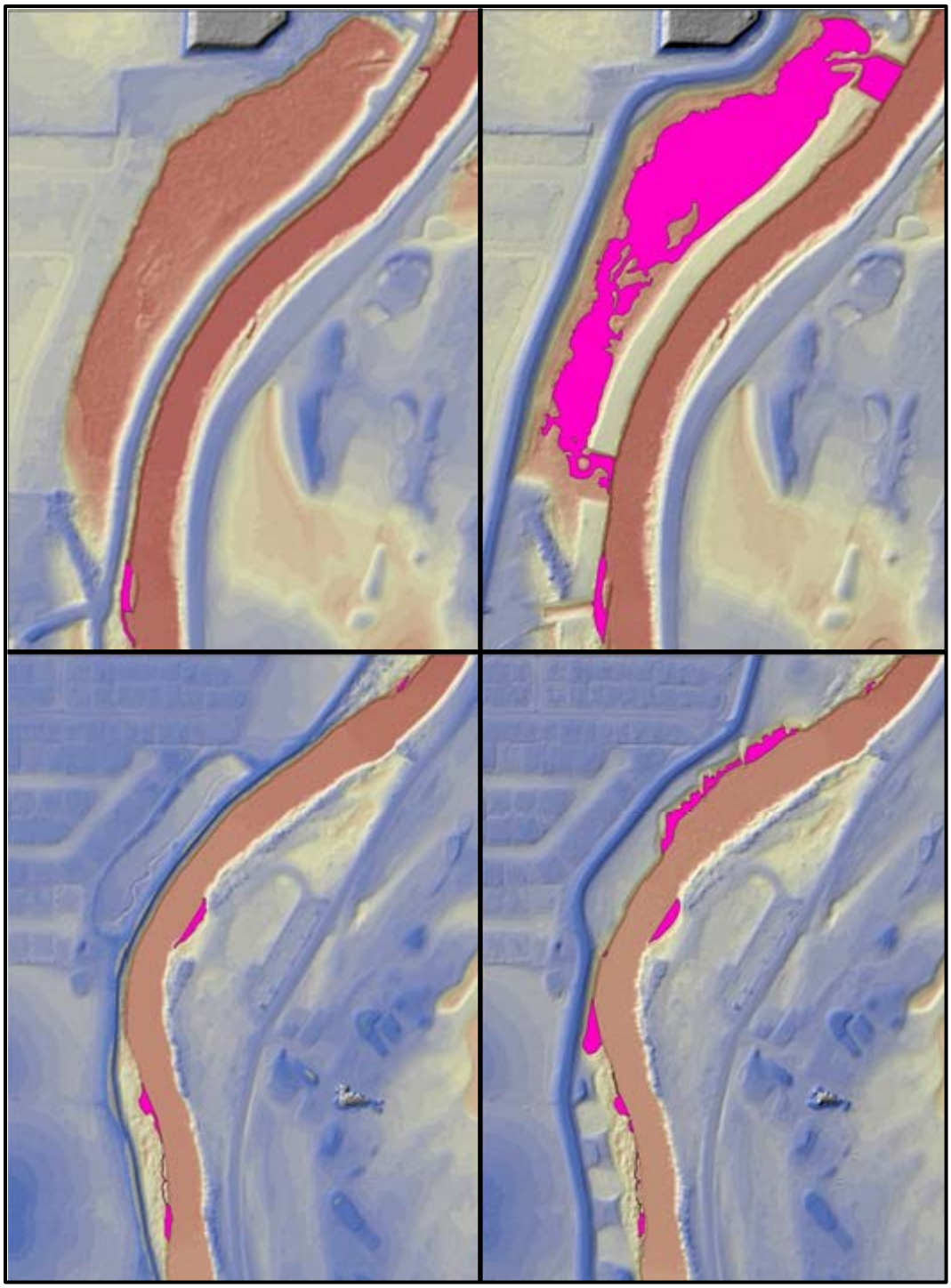

FIGURE 4. TOTAL EDGE HABITAT (PINK) IN THE PROJECT REACH BEFORE CONSTRUCTION (TWO LEFT) AT 3060 CFS, AND AFTER CONSTRUCTION (TWO RIGHT) AT 3360 CFS.

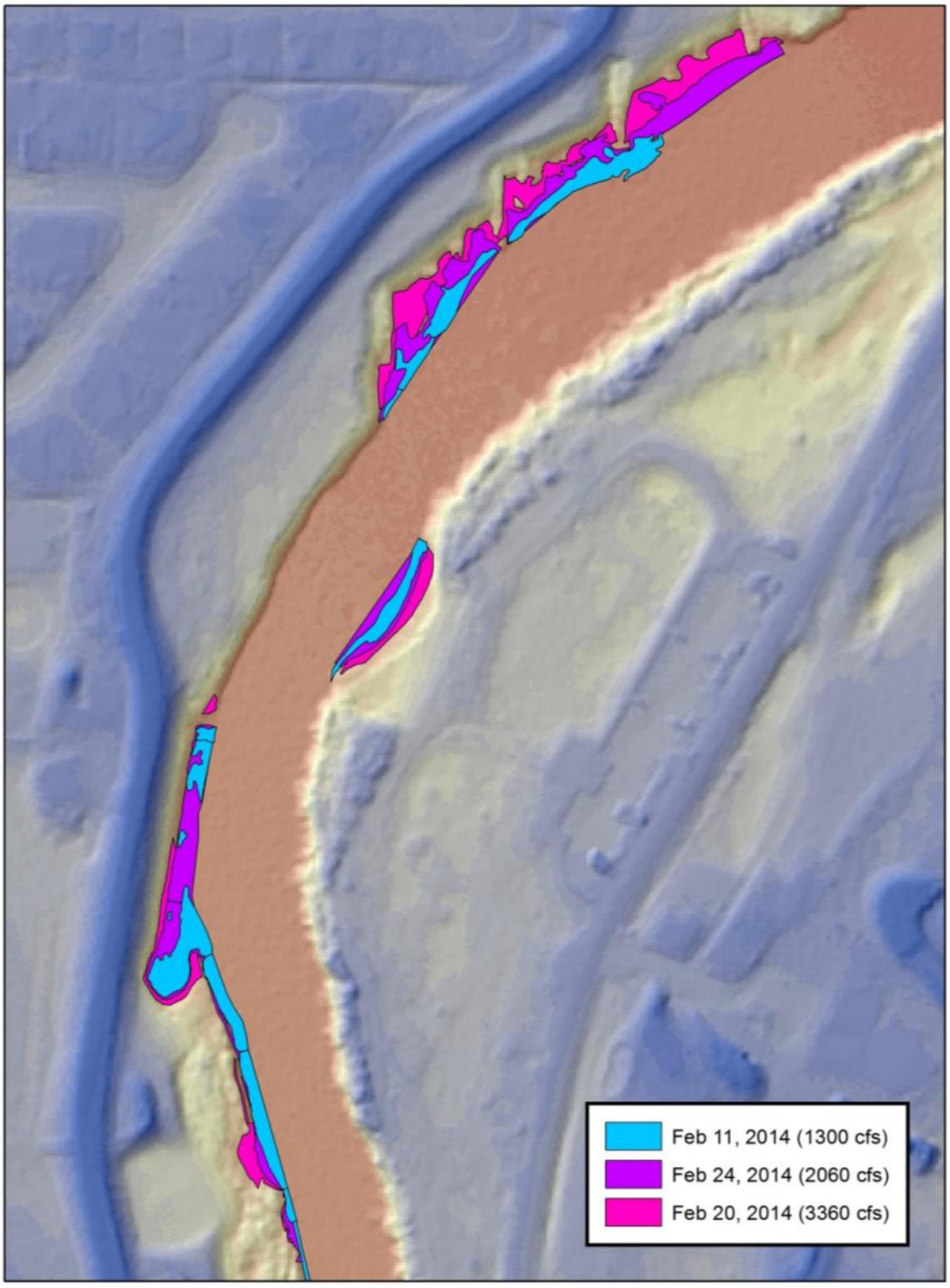

FIGURE 5. TOTAL POST CONSTRUCTION EDGE HABITAT IN THE UPPER PROJECT AREA AT 3 DIFFERENT DISCHARGES.

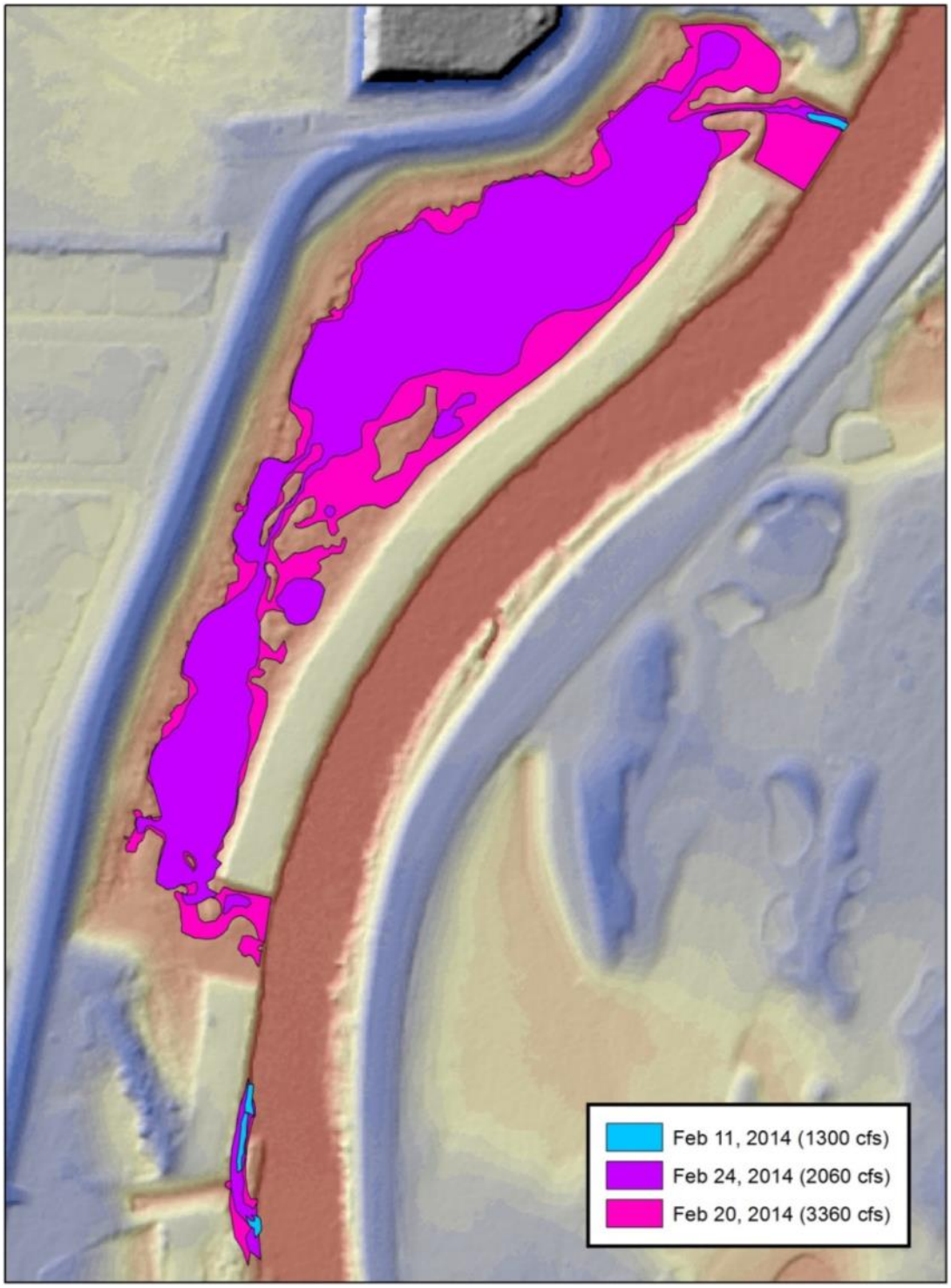

FIGURE 6. TOTAL POST CONSTRUCTION EDGE HABITAT IN THE LOWER PROJECT AREA AT 3 DIFFERENT DISCHARGES.

Edge of Water

Edge of water was mapped at the upper portion of the construction site to assess bank change and erosion (Figure 7). While it is difficult to compare edge of water from pre to post construction due to lack of pre-construction bank data at corresponding flows, we can assume that due to the steep revetted nature of the pre-existing bank that the water line changed little during higher flows. At low flow, which was comparable to the pre-existing condition at the site, the difference in edge of water lines were calculated resulting in approximately 24,048 square feet of channel was added post construction. This equates to approximately 20 square feet of channel expansion per linear foot of bank (total 1200 feet of bank mapped).

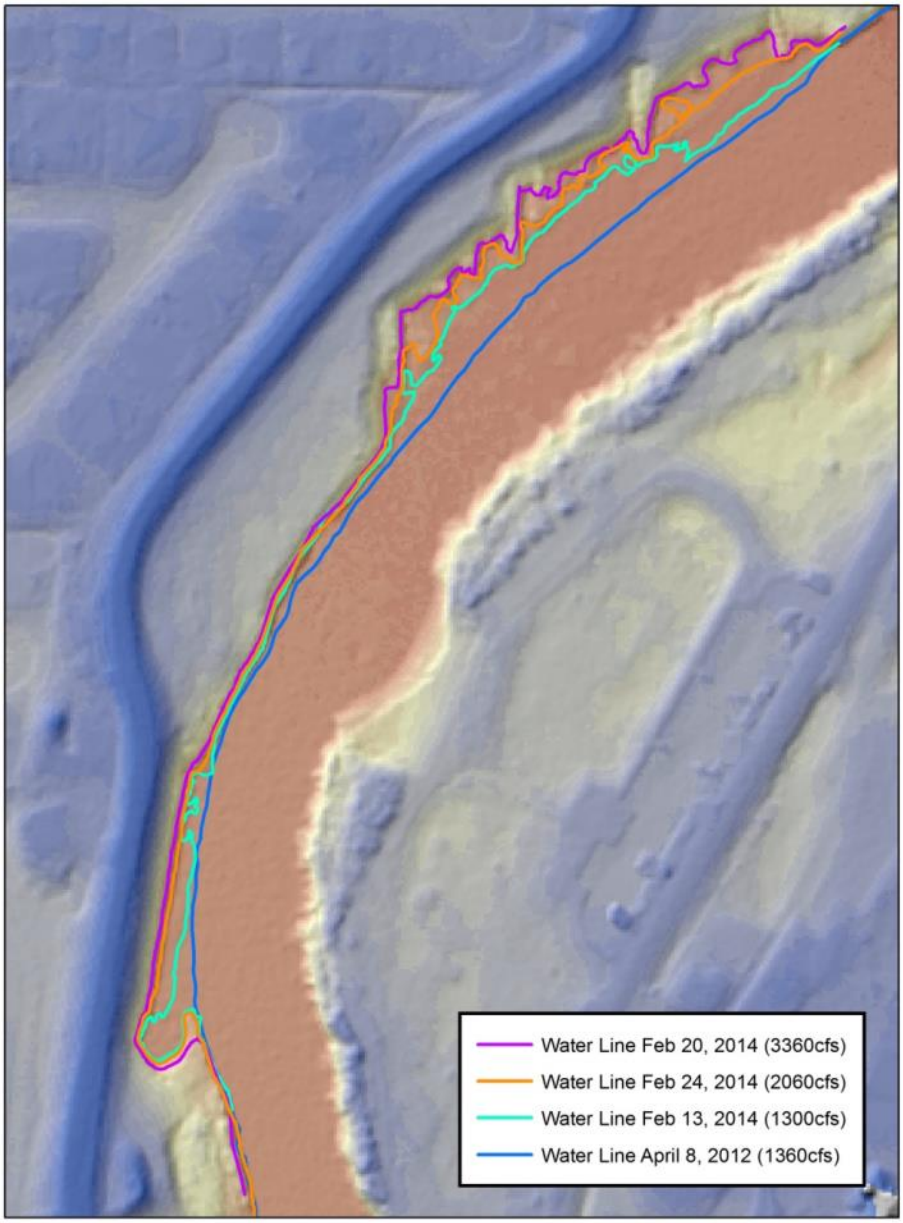

FIGURE 7. EDGE OF WATER AT ONE FLOW PRE CONSTRUCTION AND 3 FLOWS POST CONSTRUCTION

Side Channel Connection

The side channel (Wetland E) was fully connected to the river 29% of the time from January 1 – June 30, 2014 (Table 9). The flow had to be equal to or greater than 2,410 cfs for both the inlet and outlet of the side channel to be connected. The outlet was connected to the river 70% of the time, when the flow as measured at the USGS gage12113000 was equal to or greater than 1,420 cfs. This performance standard was met in Year 1. Photos taken at representative flows ranging from approximately 1,000 cfs to 4,000 cfs are shown in Figure 8.

TABLE 9. SIDE CHANNEL CONNECTION

	Connected (cfs)	**Time Connected to River (Jan1-Jun30)**
Inlet (upstream)	≥2,410	29%
Outlet (downstream)	≥1,420	70%

FIGURE 8. SIDE CHANNEL INLET (LEFT) AND OUTLET (RIGHT) AT FOUR FLOWS FROM TOP TO BOTTOM: 924 CFS ON 2/7/14, 2,010CFS ON 1/31/14, 3,000CFS ON 3/21/14, AND 4,250CFS ON 3/16/14.

A small one-foot deep trench was excavated at the side channel inlet in Summer 2014 in order to allow more water to flow into the wetland area (Figure 9).

FIGURE 9. EXCAVATED TRENCH, LOOKING TOWARD THE WETLAND, AT THE UPSTREAM NOTCH.

Placed Wood

The installed wood remained stable. Additional wood (64 pieces) not included in the design plans was placed in the floodplain near Planting Areas E and F. Of these 64 pieces, two are large enough to be classified as potential key pieces. Neither of these pieces had rootwads attached.

Six pieces of large wood were recruited to the constructed alcove between Barbs 8 and 9. Two were classified as C2, two as D3, one as E4, and one as G4. The G4 piece had a rootwad diameter of 1.2 meters.

Plant Performance and Invasive Cover

In total, the plant survival and percent cover monitoring took two staff 27 hours each, including travel time from downtown Seattle. Approximately eight hours (including travel time) were spent setting transects and taking GPS points. We estimate that future monitoring for plant survival on the right bank and percent cover on the left bank will take 15-17 hours for two staff including travel time.

Plant Survival

Survival of installed plants met or exceeded the regulatory performance standard (80% survival) in six planting areas and did not meet the performance standard in five planting areas (Table 10). Planting Area A was the construction staging area, and soil compaction is possibly the reason for low plant survival in this area. Planting Area H is higher than other areas and in full sun, therefore, potentially drier

though watering treatments were the same across the entire site. Some plantings within the Isaac Evans Park buffer (Planting Areas J, K, and L) appeared to be overcome by blackberry and snowberry. Many plantings within the Issac Evans Main Park field (Planting Area J) were mowed over by Parks maintenance staff in some areas and others died potentially due to unexpected winter inundation. Planting Area B was not subject to survival performance standards. However this area was impacted by construction activities to remove additional rock and therefore was entirely replanted in fall of 2014. The irrigation study area was not included in the calculations for Planting Area C.

TABLE 10. PERCENT SURVIVAL OF INSTALLED PLANTS ON THE LEFT BANK (PLANTING AREAS A-H) AND THE RIGHT BANK (PLANTING AREAS I-L)

Planting Area	Percent Survival
A	**67.3%**
C	87.3%
D	84.9%
E	80.0%
F	87.1%
G	88.6%
H	**76.6%**
I	82.2%
J	**57.9%**
K	**70.0%**
L	**63.0%**

While additional planting was needed in five planting areas to address low survival, we chose to replant all areas to 100% of the initial installation. This method was chosen to avoid the need for repeat plantings over a number of years and to circumvent staggered ages of plants to water and care for. The chart below summarizes the total plant replacement of 4123 native plants within the 12 different planting areas (Table 11).

TABLE 11. REPLACEMENT PLANTING ON THE RIGHT AND LEFT BANKS

PLANT REPLACEMANT	Area "A"	Area "B"	Area "C"	Area "D"	Area "E"	Area "F"	Area "G"	Area "H"	Area "I"	Area "J" Main Park	Area "K" Park Buffer	Area "L" Park Lawn	Total Plant Replacment
Percent Replacement	**33%**	**100%**	**13%**	**15%**	**20%**	**13%**	**11%**	**24%**	**18%**	**42%**	**30%**	**37%**	
Trees	206	538	92	32	130	2	72	159	93	97	9	11	1441
Shrubs	991	0	197	160	559	124	197	440	14	0	0	0	2682
Total	1197	538	289	192	689	126	269	599	107	97	9	11	4123

Native Vegetation Cover

Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species, does not have a performance standard set for Year 1 following planting. The Year 2 performance standard is 15% cover. The 15% performance standard was exceeded in Planting Areas C and D (Table 12).

TABLE 12. PERCENT COVER OF NATIVE WOODY AND INVASIVE PLANT SPECIES

Planting Area	Native Woody	Invasive
A	11.8	3.0
B	0.0	0.0
C	18.2	**25.1**
D	17.5	6.9
E	8.8	8.0
F	11.5	**31.5**
G	9.8	3.3
H	8.0	0.3

Invasive Species

Invasive vegetation exceeded the 10% performance standard in two planting areas: Planting Area C and Planting Area F (Table 11). The dominant invasive species in Planting Area C was reed canarygrass. This was predominately located along the wetland transect. The dominant invasive in Planting Area F was Himalayan blackberry. This area was almost entirely dominated by blackberry prior to project implementation. The blackberry was removed, and the area was sheet mulched using cardboard, but the blackberry has grown through the sheet mulch in many locations.

Plant Recruitment Study

There were no significant differences in either weed or native plant percent cover, or the number of native seedlings recruited among the four treatments. Among all treatments herbaceous groundcover was dominated by common native and non-native weeds, collectively grouped for this study as “forbs.” Noxious weeds and weeds of concern in the herbaceous layer were separated from this forbs class and termed “invasive forbs.”

Cottonwood was the dominant native tree seedling that naturalized in all treatment plots. Average cottonwood recruitment was 201,000 seedlings per hectare. This is substantially lower than the 308,000 to 1.43 million seedlings per hectare observed at another King County recruitment study, the McElhoe Pearson project site. The soils in the experimental plots at the Reddington were compacted as it was used for a staging area, which may in part explain the low recruitment rate.

Weed treatment occurred in late summer; therefore no treatment effect is anticipated to be observed until the second growing season. It is also unlikely that a watering effect or interaction effect of the treatments will be noticeable until the plots are fully occupied and competition for light and water resources becomes more severe.

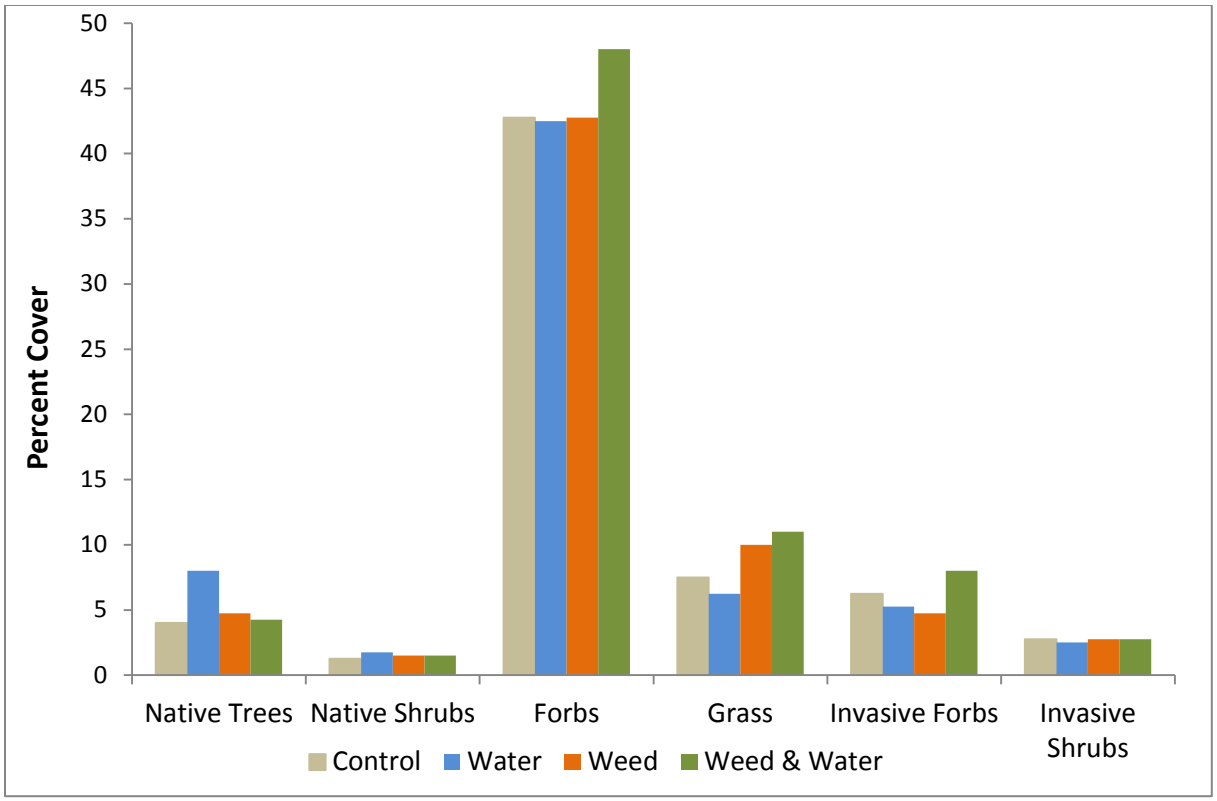

FIGURE 10. PERCENT COVER NATIVE AND INVASIVE PLANTS IN THE TREE SEEDLING RECRUITMENT STUDY

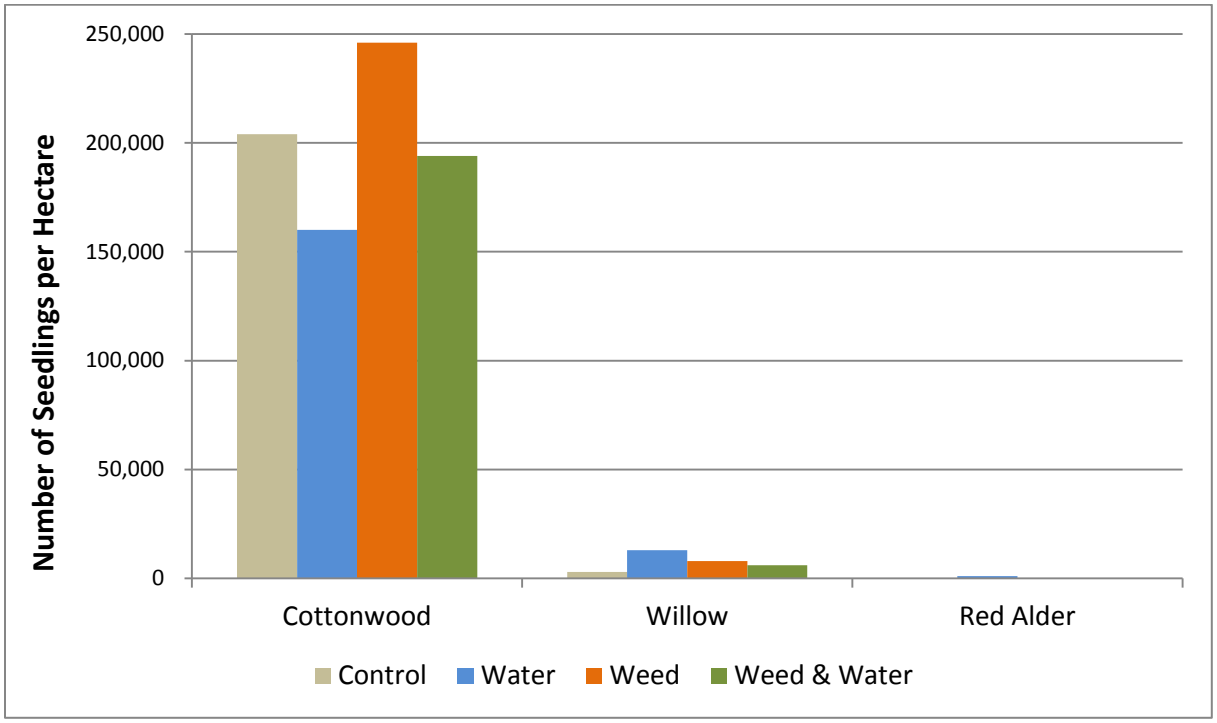

FIGURE 11. NUMBER OF NATIVE TREE SEEDLINGS PER HECTARE IN THE TREE SEEDLING RECRUITEMENT STUDY

Irrigation Study

No significant difference in plant survival was observed among irrigation treatment categories (Table 13).

TABLE 13. PERCENT SURVIVAL OF INSTALLED PLANTS IN EACH IRRIGATION TREATMENT CATEGORY. SAMPLE SIZE (N) IN PARENTHESES

Treatment	Snowberry	Dogwood	Total
Control (No water)	99.1% (113)	100% (118)	99.6% (231)
Hand Watering	100% (115)	100% (116)	100% (231)
Drip Irrigation	99.1% (106)	100% (116)	99.6% (222)

The cost to install the irrigation system, using materials recycled from a previous site was approximately $2,300. Each site was watered four times. One session was dropped from the data analysis due to a break in the irrigation system which resulted in the tank being filled twice, doubling the cost for that watering session.

The average cost for laying out hoses and hand watering plants was $0.39 per plant. The cost to layout hoses, fill tanks, and do maintenance while tanks were filling, was $0.60 per plant. If the cost of installation is factored in for all four waterings in 2014, the cost for drip irrigation was $3.00 per plant. There were no costs associated with irrigation for the unwatered plots.

Fish Use

At the four fish sampling locations within the Reddington project reach, a total of 167 fish and 11 species were captured over 3 unique sampling events (Table 14). The species captured included chinook, chum, coho, and pink salmon, as well as cutthroat trout, rainbow trout/steelhead, dace, largescale sucker, lamprey, mottled sculpin, prickly sculpin, slimy sculpin, and threespine stickleback. All salmonids captured were juveniles.

TABLE 14. TOTAL NUMBER OF FISH CAUGHT BY GROUP DURING ALL FISH SAMPLING EVENTS

	Chinook	Chum	Coho	Pink	Cutthroat	Rainbow	Dace	L.S. Sucker	Lamprey	M. Sculpin	P. Sculpin	S. sculpin	T.S. Stickleback
Reddington	79	11	33	10		3	12	3	1	3	9	3	
Control	21	1	19	1	1	1		1		9	29	8	4
Reference	23	1	11			4			1	2	8	2	
Riverview	31	1					2	1				1	
Grand Total	**154**	**14**	**63**	**11**	**1**	**8**	**14**	**5**	**2**	**14**	**46**	**14**	**4**

Shock time for all Reddington, control, and reference sampling events ranged from 0.72 minutes to 4.73 minutes. Mean shock time was consistent between groups, with 2.96 minutes for Reddington, 3.21 for Riverbend, 2.99 for Control, and 3.03 minutes for reference sites. A one way ANOVA test determined that there is no statistical difference between shock times for each group.

CPUE was calculated for all species for each sampling group (Table 15). One way repeated measures ANOVA was performed for CPUE values for each species of fish captured to test the null hypothesis that there is no difference among the sampling groups (Reddington, Control, Reference).

TABLE 15. CPUE MEAN AND RANGES (IN PARENTHESIS) FOR SELECT SPECIES

	Chinook	Chum	Coho	Pink	Rainbow	Total Sculpin
Control (n=3)	1.252 *(0-5.333)*	0.035 *(0-0.311)*	1.175 *(0-4.839)*	0.035 *(0-0.311)*	0.108 *(0-0.968)*	2.231 *(0.411-5.333)*
Reference (n=3)	0.914 *(0.403-1.558)*	0.028 *(0-0.256)*	0.377*(0-1.104)*	0	0.176 *(0-0.805)*	0.693 *(0-2.791)*
Reddington (n=4)	**2.403 *(0-6.783)***	**0.339 *(0-0.833)***	**0.934 *(0-3.038)***	**0.229 *(0-1.629)***	**0.086 *(0-0.403)***	**0.509 *(0-2.880)***
Riverview SC (n=1)	3.109 *(2.270-4.000)*	0.093 *(0-0.278)*	0	0	0	0.093 *(0-0.278)*

Chinook CPUE was found to be significantly different between groups (P=0.006) (Figure 12). A pairwise comparison was performed between each group, and showed that Chinook CPUE at Reddington sites was significantly greater than both control (P=0.009) and reference sites (P=0.019). Figures 13 and 14 also show distribution of CPUE scores for Chinook and coho between sites as well as the sampling group.

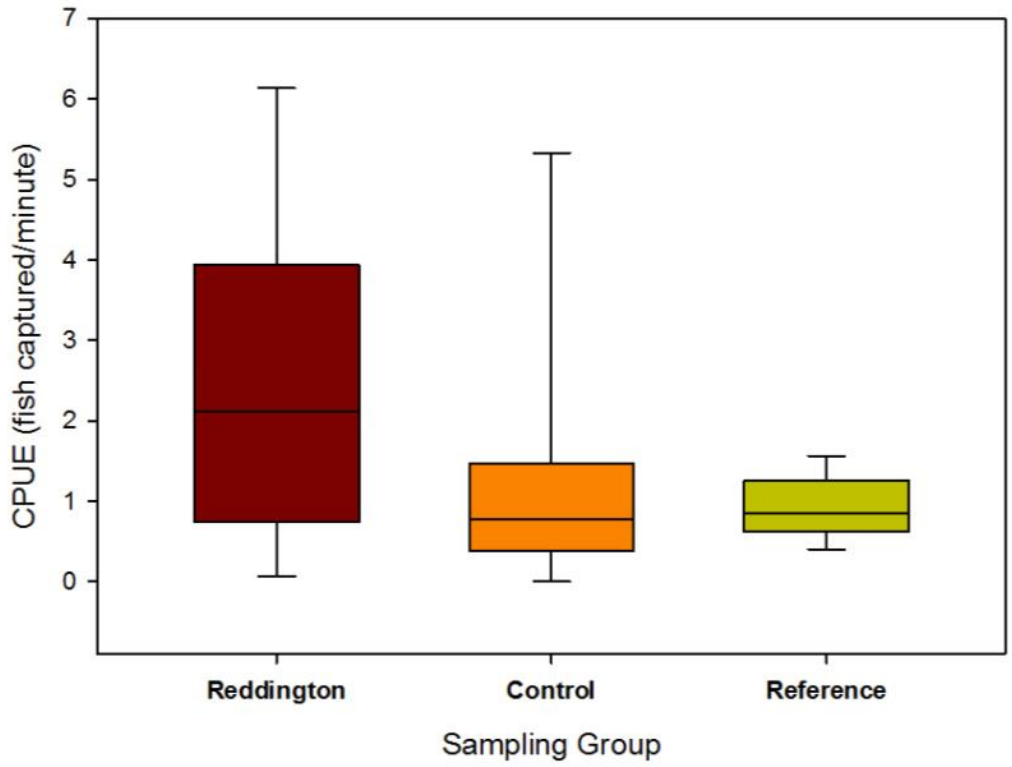

FIGURE 12. CHINOOK CPUE COMBINED FOR EACH SAMPLING GROUP.

No significant difference was found for any other species except for sculpins. Total sculpin CPUE was found to be significantly greater at control sites than both Reddington and reference sites (P=0.026). For species where no significant difference among groups was found, low CPUE values and low numbers of fish captured resulted in lower than desired statistical power. This would result in a test that is less likely to detect a difference when one actually exists.

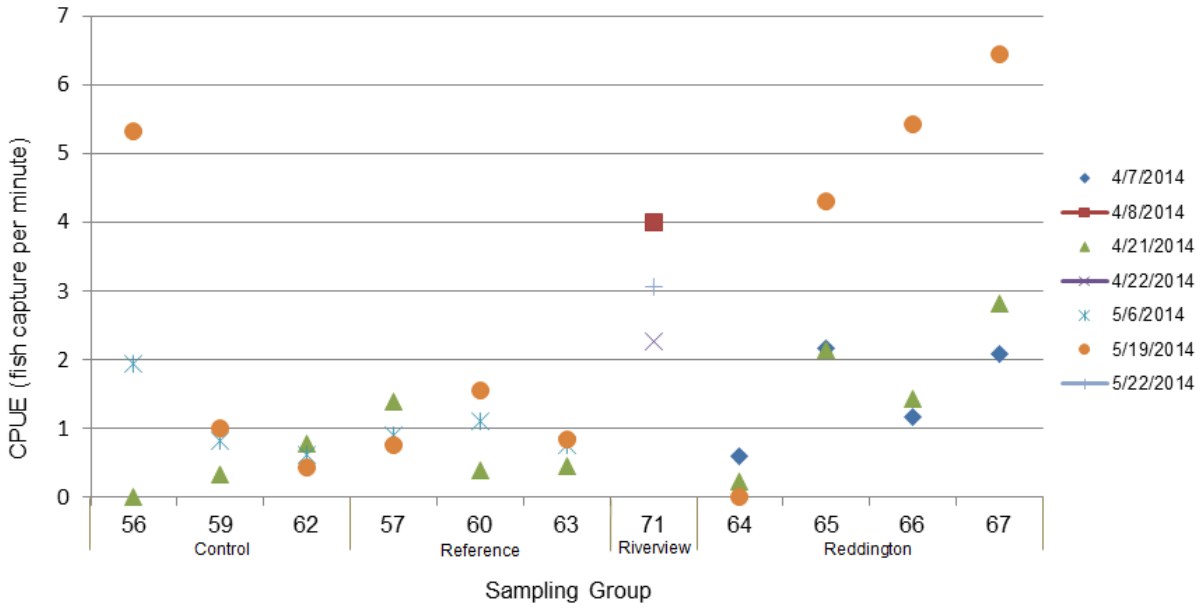

FIGURE 13. JUVENILE CHINOOK CPUE

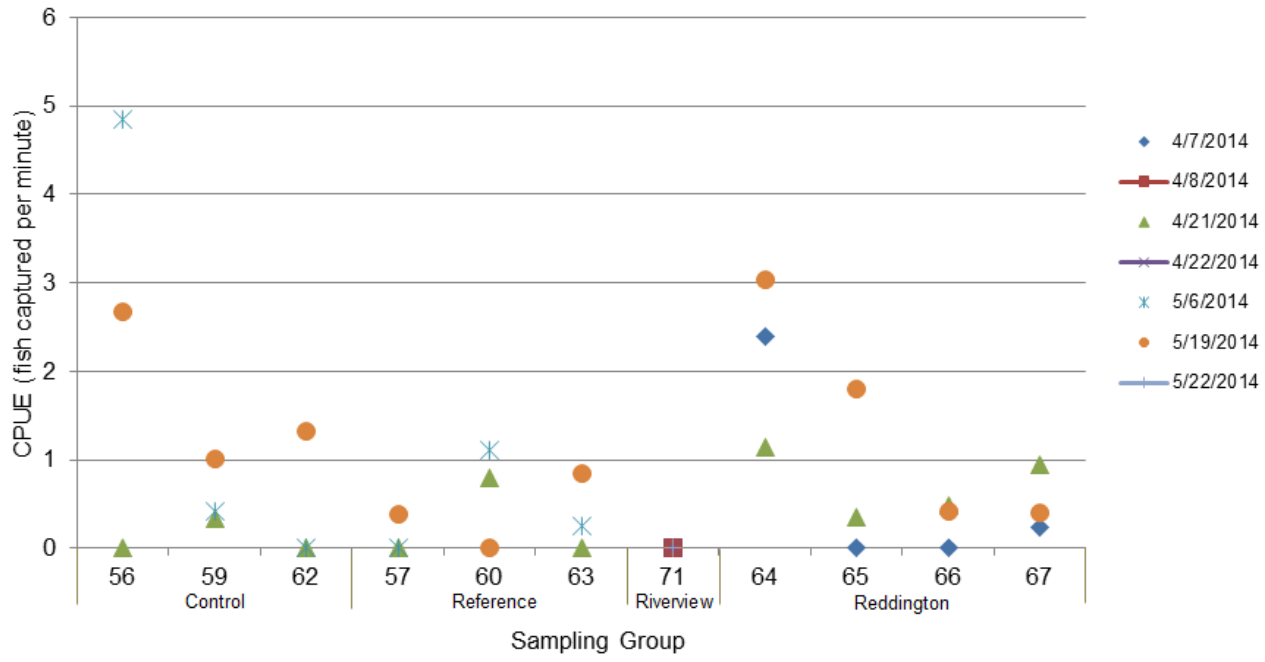

FIGURE 14. JUVENILE COHO CPUE

During sampling, length was measured for all fish captured. By comparing lengths between Reddington, Reference, and Control, we can assess whether juvenile fish growth is different at Reddington than the other sampling locations (Figure 15). To measure this, juvenile chinook were used because this group

had the most data and was composed of only one age class (unlike coho). An Analysis of Covariance (ANCOVA) was used to test both mean length for chinook, and growth rate over the data collection period. No significant difference was detected for either mean length (F=0.02, P=0.98), or growth rate (F=0.12, P=0.89) between Reddington, Control, and Reference sites.

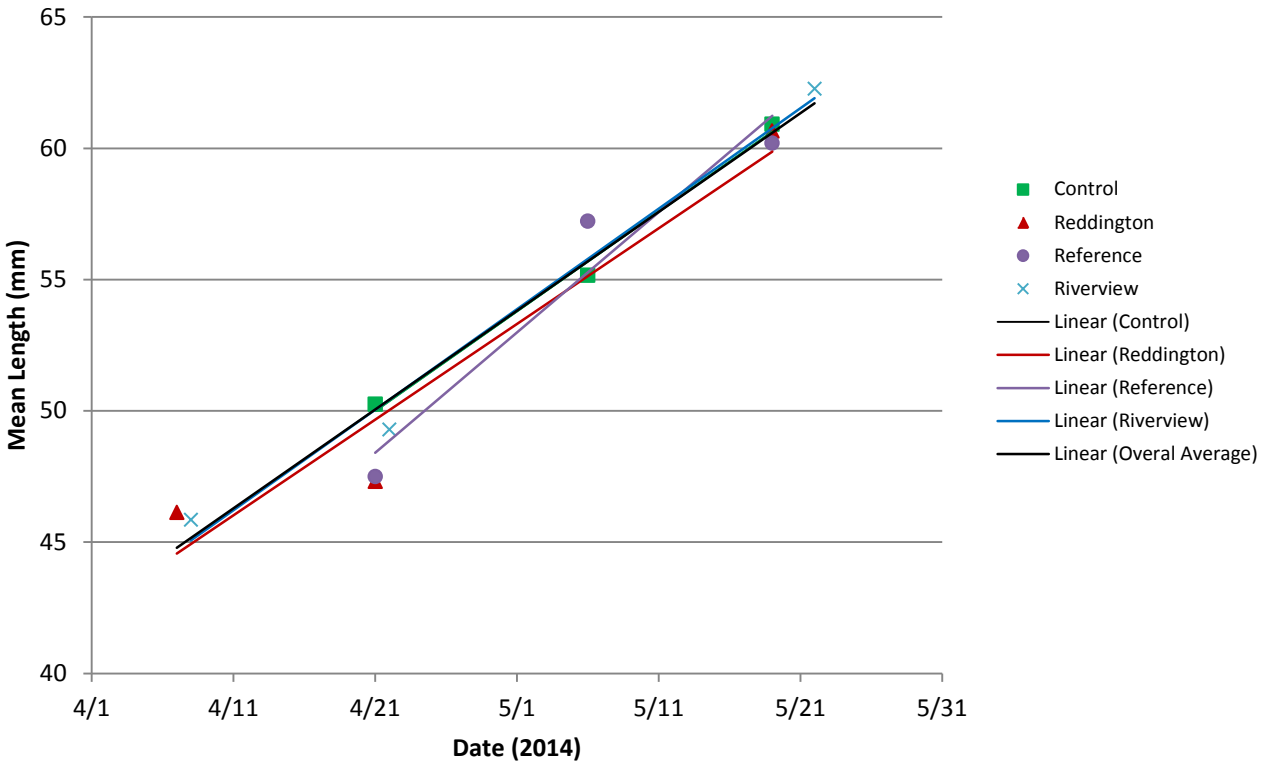

FIGURE 15. MEAN LENGTH OF JUVENILE CHINOOK CAPTURED FOR EACH DATE AND GROUP WITH LINEAR REGRESSIONS.

Sampling bias

Single pass electrofishing in a large river environment is likely to underestimate the total number of fish in the sampling reach (Nielsen et al 1983). Large rivers are inherently difficult to sample which reduces efficiency and fish are more likely to flee from sampling efforts than be attracted to them. Without block nets to isolate the fish and the ability to make multiple passes at a site, this method is best suited to providing a catch per unit effort index rather than accurate population assessments. While this data cannot provide an accurate census, it can be used to compare sampling reaches on a spatial and time scale.

There are disadvantages to the semi-quantitave nature of our sampling methods and the available habitats sampled. Sampling efficiency likely changes between shallow bar type habitats where fish would have less area to escape the electric field versus deeper bank habitats where escape would be easier. Overhanging vegetation at treatment reaches likely influenced sampling efficiency as well. While our sampling locations were not inundated by riparian vegetation, overhanging vegetation at the reference sites likely hindered sampling efficiency. At these sites, the samplers must maneuver both

boat and nets under overhanging vegetation, which could directly reduce efficiency as well as give the fish both extra time and space to escape. The effect of vegetation and/or deep water would likely result in a CPUE lower than different habitat with similar fish densities.

Areas with high densities of fish may be biased towards a CPUE that underestimates the actual amount of fish. Simpson (1978), found that population density was inversely related to efficiency, likely because dense populations may result in less effective dip-netting or group fright response.

Water temperature affects efficiency through changes in fish metabolism, which can increase or decrease their ability to perceive and escape an electrical field, and also through changes in water conductivity (Nielsen et al 1983). Temperature also increases the actual conductivity of water, which changes the efficacy of shocking. Daily mean river temperatures (measured at King County gauge GRT 40 in Tukwilla) ranged from 9.21 deg C on 4/7 to 11.69 on 5/19, which likely resulted in little noticeable difference in fish behavior.

Electrofishing is known to produce biased estimates of fish size (Anderson 1995). Larger fish are more susceptible to an electric field, and are often selected for by netters. Smaller fish may be more difficult to see, especially in the presence of larger fish. Also, sculpin numbers may likely be biased due to their benthic nature and inconspicuous coloring, as well as netter preference for salmonids.

Side Channel Performance

The Reddington side channel (site 64) results are not likely representative of the habitat present. The main portion of the side channel could not be sampled due to access (outlet was sampled instead), and the side channel was disconnected or partially connected during sampling which may have inhibited recruitment into the habitat.

Because the side channel was largely disconnected, it functioned more as a backwater than a side channel during the sampling period. Chinook CPUE at this site was highest earlier in the sampling period when flows were highest and the side channel was connected, though this could be due to chinook fry being smaller therefore selecting for this type of off channel habitat. Because this side channel was functioning more as a backwater at the time of sampling, the Riverview side channel CPUE data is included to show what the Reddington side channel may be like when functioning as a side channel.

V. Discussion

The questions posed below are based on the monitoring objectives in Table 1.

Question 1: Was the project constructed according to design specifications?

In general, the as-built condition satisfied the design objectives. However, the inlet to the side channel (Wetland E) was approximately one foot higher than designed.

Implications of findings:

Though the performance standard for side channel connection to the mainstem river was met, the difference in side channel inlet elevation resulted in less water flowing through the side channel during Chinook rearing. The implications of this are less off-channel habitat available during the rearing period.

Recommendations for future work:
None at this time.

Question 2: Did the area of slow-water habitat increase?
Yes, the area of slow-water edge habitat increased significantly over the baseline condition. In fact, the project resulted in a measured 1911% increase in critical low flow rearing habitat in the project reach at 3360 cfs (3060 cfs pre restoration and 3360 cfs post restoration).

Implications of findings:
Juvenile salmonids will have significantly more habitat available for rearing as well as refuge during high flow conditions.

Recommendations for future work:
Continue monitoring edge habitat in Years 5 and 10 post-construction to detect changes as a result of erosion, deposition, or other deformation associated with project implementation.

Question 3: Did the side channel provide Chinook rearing habitat?
Yes, the side channel was fully connected 29% of the time during the Chinook rearing period (January – June) and the outlet was connected 70% of the time, thereby providing both backwater and side channel habitat. At 3360 cfs, the side channel added 1.82 hectares of critical low velocity habitat, while at 2060 cfs 1.24 hectares were added. Sampling was limited to the outlet channel at low flows which likely underestimated chinook abundance, however, juvenile chinook were found using this habitat during 2 of 3 sampling events.

Implications of findings:
Juvenile salmonids have significantly more off-channel habitat available for rearing as well as refuge during high flow conditions.

Recommendations for future work:
Continue monitoring side channel connection using remote cameras in Years 3, 5, 7 and 10 post-construction to document flow-through and backwater conditions. Add side channel connection monitoring in Year 2 (2015) to document changes resulting from additional inlet excavation in 2014.

Question 4: Were the key wood pieces stable?
Yes, the key pieces were all intact. Six pieces of wood (two were potential key pieces) were recruited to the alcove between Barbs 8 and 9.

Implications of findings:
The anchoring technique proved effective for keeping the installed wood in place. Currently, wood seems most likely to recruit in the slow water area between the two downstream-most barbs. In the future, we may also see wood recruitment in the wetland.

Recommendations for future work:
Continue monitoring in Years 5 and 10. Monitor immediately following Phase III or higher flood events to determine whether higher flows dislodge the installed wood.

Question 5: Did 80% of installed plants survive the first growing season?
No, five of the eleven planting areas (Area A, H, J, K and L) did not meet the performance standard.

Implications of findings:
While additional planting was needed in five planting areas to address low survival, we chose to replant all areas to 100% of the initial installation (4123 native plants) to avoid the need for repeat plantings and to circumvent staggered ages of plants to water and care for.

Recommendations for future work:
Supplemental plants were installed in all planting areas between November 13, 2014 and December 20, 2014. This will raise survival above the required performance standards. Continued maintenance will be paramount to ensure healthy plant establishment. Attention to timely water and weed control should also help ensure survival so that the standards of success can be reached at or before the end of the monitoring period. The City of Auburn has agreed a higher level of attention during mowing to prevent future mortality during maintenance. If needed, flagging or fencing will be considered within Isaac Evans Park.

Construction staging areas should receive additional care and attention (e.g., soil ripping) prior to planting in order to compensate for compaction. Higher elevation and full sun areas that appear drier may warrant additional watering and close monitoring during the dry season. Invasive species removal (in this case, blackberry) should be aggressive enough to provide young plants enough room to become established. Larger and more frequent use of sheet mulch could be considered in appropriate locations for weed suppression.

Question 6: Is native woody vegetation cover approaching Year 2 performance standards?
In two planting areas (C and D), native woody vegetation cover has already exceeded performance standards. In the other left bank planting areas, the Year 2 performance standard for native woody cover has not been reached.

Implications of findings:
If plants continue to grow, survival is good next summer, and native recruits survive, we should meet performance standards in some of the planting areas (e.g., Areas C and D). Additional planting may be necessary to meet Year 2 performance standards for native woody vegetation cover in some planting areas (e.g., Areas E, G, and H).

Recommendations for future work:
Supplemental plants were installed in all planting areas between November 13, 2014 and December 20, 2014. Native plant maintenance and monitoring will be continued to ensure that the cover performance standards will be met.

Question 7: Is invasive plant cover lower than 10%?

In two planting areas (C and F), invasive plant cover is significantly higher than 10%. In the other left bank planting areas, invasive plant cover met the performance standard.

Implications of findings:
High invasive plant cover can impede native plant survival and growth.

Recommendations for future work:
Repeat weed treatments in Planting Areas C and F. Continue spot treatments for bindweed, knotweed, and any King County Class A noxious weeds in 2015.

Question 8: Did weeding and watering affect natural plant recruitment?
There were no significant differences in native tree seedling recruitment or native or invasive plant cover among treatments.

Implications of findings:
Treatment effects are not anticipated until after the second or third growing season, when competition for space, water and light becomes more severe.

Recommendations for future work:
Repeat weed and water treatments next year and re-measure at the end of the second growing season.

Question 9: Did irrigation technique affect plant survival?
Plant survival was not significantly different among irrigation treatments (no water, drip irrigation, or hand watering) for the species selected. More drought sensitive species would likely have benefitted from irrigation. Irrigation would likely have been a greater factor the site if it had more sun exposure or better drained soils. The site used was an east facing slope with a mature wetland forest to the east which likely reduced drying.

The cost to water the plants with drip irrigation was substantially greater than the cost of hand watering, especially if the cost of installation and eventual removal is included.

Implications of findings:
This could reduce plant watering costs in the future. It is important to note that this study was conducted using hardy plant species (snowberry and dogwood), and was done in an area that received morning shade from the adjacent forested wetland.

Recommendations for future work:
While the initial results appear to be definitive, it may be valuable to continue the study in 2015 and beyond to observe the effects of the different irrigation treatments on plant cover. Future similar studies should be conducted on sites with harsher conditions and with less drought tolerant species. Data from such studies could be used to refine irrigation strategies to improve performance and reduce costs.

Question 10: Did juvenile salmonids preferentially use constructed habitat at Reddington?
Yes, significantly higher catch rates at the constructed Reddington habitats indicate that Chinook prefer the newly constructed habitats over the Reference and Control sites which represent pre-project

conditions in the Reddington Reach. While other salmonids were not found to be significantly greater within the project itself, several individual sampling locations had exceptionally high catch rates.

Implications of findings:

These findings suggest that the Reddington project benefits juvenile Chinook salmon in the Green River, and that flood infrastructure and habitat improvement can go hand in hand.

Recommendations for future work:

Maximize the amount of low flow edge habitat for juvenile salmonids by opening the channel and adding channel complexity that is activated by a wide range of flows.

VI. References

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Appendix A – As-built planting plans with monitoring transects

RECORD DRAWING

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——— MONITORING TRANSECT LOCATIONS (LABEL AT START POINT)

SEC. 32, TWN. 22, R. 5 SW, W.M.

SEC. 5, TWN. 21, R. 5 NW, W.M.

SEC. 31, TWN. 22, R. 5 SE, W.M.

SEC. 6, TWN. 21, R. 5 NE, W.M.

GREEN RIVER

CUT AND TREAT BLACKBERRY ALONG EDGE OF FIELD, APPROXIMATE WIDTH OF TREATMENT ZONE IS 30 FEET.

NATURAL RECRUITMENT STUDY AREA 141' x 141'

A

A1

A2

A3

N: 128747.16
E: 1299752.39

N: 128751.10
E: 1299569.77

N: 128076.43
E: 1299827.96

32 T 5
31 A 6

MATCHLINE - SEE SHEET L6

50 0 50 100 150
SCALE IN FEET

CALL 2 WORKING DAYS
BEFORE YOU DIG
1-800-424-5555
(UNDERGROUND UTILITY LOCATIONS ARE APPROX.)

NOTES:

1. DO NOT PLANT NATURAL RECRUITMENT AREA.
2. PLANT THIMBLEBERRY AND ROSE ALONG WEST EDGE OF PLANTING AREA.
3. DO NOT PLANT 2-GALLON STOCK IN AREA "A".

A. Fallow Field
147,892 sqft

Trees	12' Spacing	
Species	**Number**	
Cottonwood (Stakes)	~~510~~	260
Alder	~~280~~	140
Western Red Cedar	~~120~~	60
Douglas Fir	~~120~~	60
Tree Totals	~~**1,030**~~	520
Shrubs	**7' Spacing**	
Species	**Number**	
Black Twinberry	90	
Red Twig Dogwood	600	
Snowberry	1,090	
Ninebark	150	
Ocean Spray	~~270~~	160
Tall Oregon Grape	100	
Thimbleberry	~~300~~	123
Baldhip Rose	420	
Shrub Totals	~~**3,020**~~	2,733

NUM.	REVISION	BY	DATE
R1	RECORD CHANGES	S.M.	12-8-2014
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PROJECT MANAGER:	ERIK PETERS, P.E.	11/20/2013
DESIGNED:	JOHN KOON	11/20/2013
REVIEWED:	LISA BRANDT	11/20/2013
CAD DESIGN:	KAY KITAMURA	11/20/2013

FUNDING SOURCE No. --
PROJECT No. 1112035
CONTRACT No. C00817C13

ERIK G. PETERS
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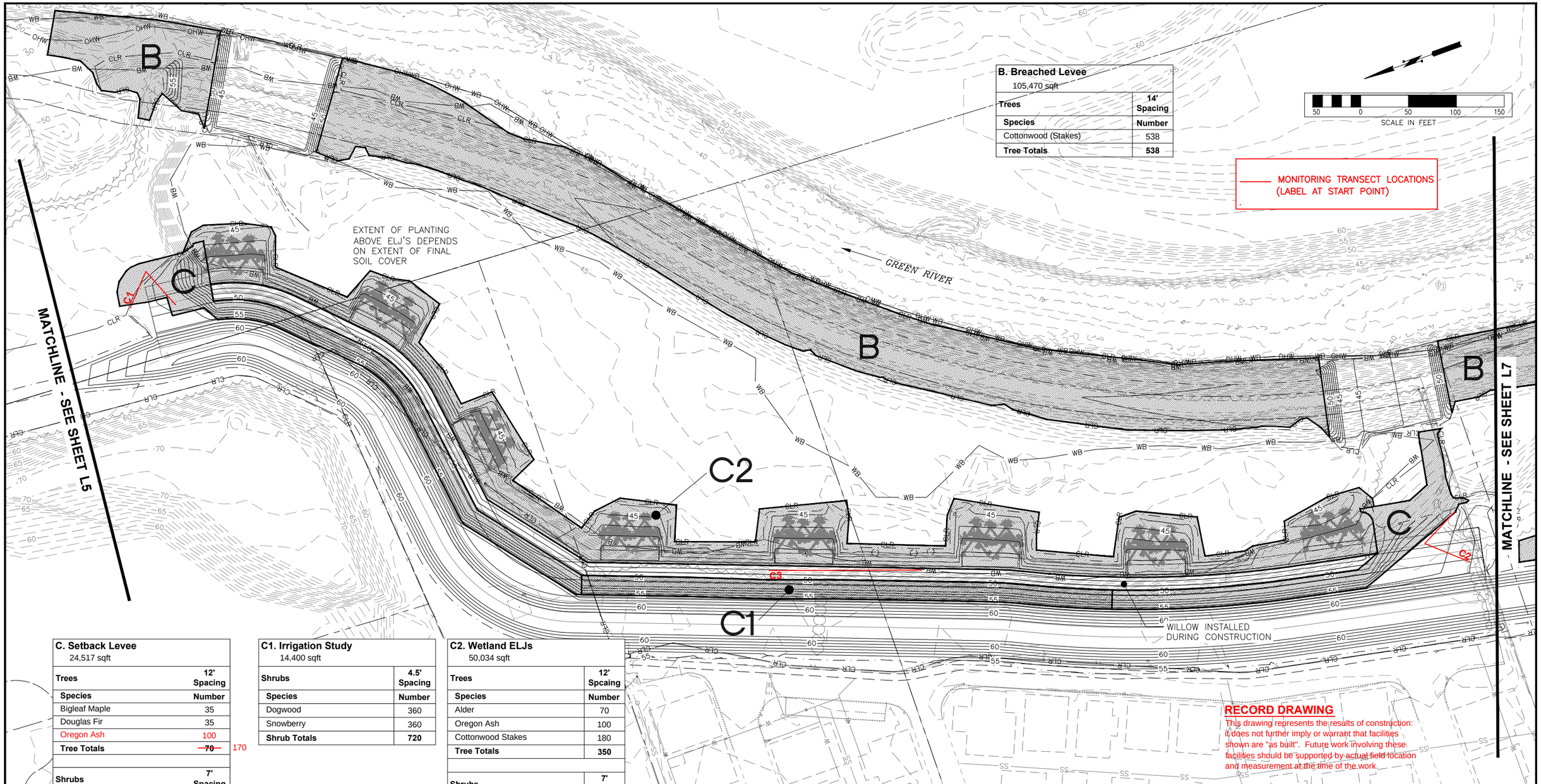
King County
Department of Natural Resources and Parks
Water and Land Resources Division
River and Floodplain Management Section
Christie True, Director

REDDINGTON LEVEE SETBACK

PLANTING PLAN - NOVEMBER 2013 REVISION

SHEET L5 OF 107 SHEETS



B. Breached Levee 105,470 sqft	
Trees	**14' Spacing**
Species	**Number**
Cottonwood (Stakes)	538
Tree Totals	**538**

C. Setback Levee 24,517 sqft	
Trees	**12' Spacing**
Species	**Number**
Bigleaf Maple	35
Douglas Fir	35
Oregon Ash	100
Tree Totals	~~70~~ 170
Shrubs	**7' Spacing**
Species	**Number**
Dogwood	120
Snowberry	80
Baldhip Rose	50
Black Twinberry	80
Thimbleberry	70
Salmonberry	100
Shrub Totals	**500**

C1. Irrigation Study 14,400 sqft	
Shrubs	**4.5' Spacing**
Species	**Number**
Dogwood	360
Snowberry	360
Shrub Totals	**720**

C2. Wetland ELJs 50,034 sqft	
Trees	**12' Spcaing**
Species	**Number**
Alder	70
Oregon Ash	100
Cottonwood Stakes	180
Tree Totals	**350**
Shrubs	**7' Spacing**
Species	**Number**
Black Twinberry	270
Cluster Rose	130
Dogwood	220
Salmonberry	200
Thimbleberry	200
Shrub Totals	**1,020**

RECORD DRAWING

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NOTES:

1. PLANTING AREA "B" MAY BE PLANTED AFTER FIRST SIGNIFICANT HIGH FLOWS.
2. START PLANTING AREA "C" 6 FEET VERTICAL BELOW TOP OF LEVEE. DO NOT PLANT TREES ON LEVEE SLOPE.
3. AREA "C1" IS IRRIGATION STUDY AREA.

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REVIEWED:	LISA BRANDT	11/20/2013
CAD DESIGN:	KAY KITAMURA	11/20/2013

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River and Floodplain Management Section
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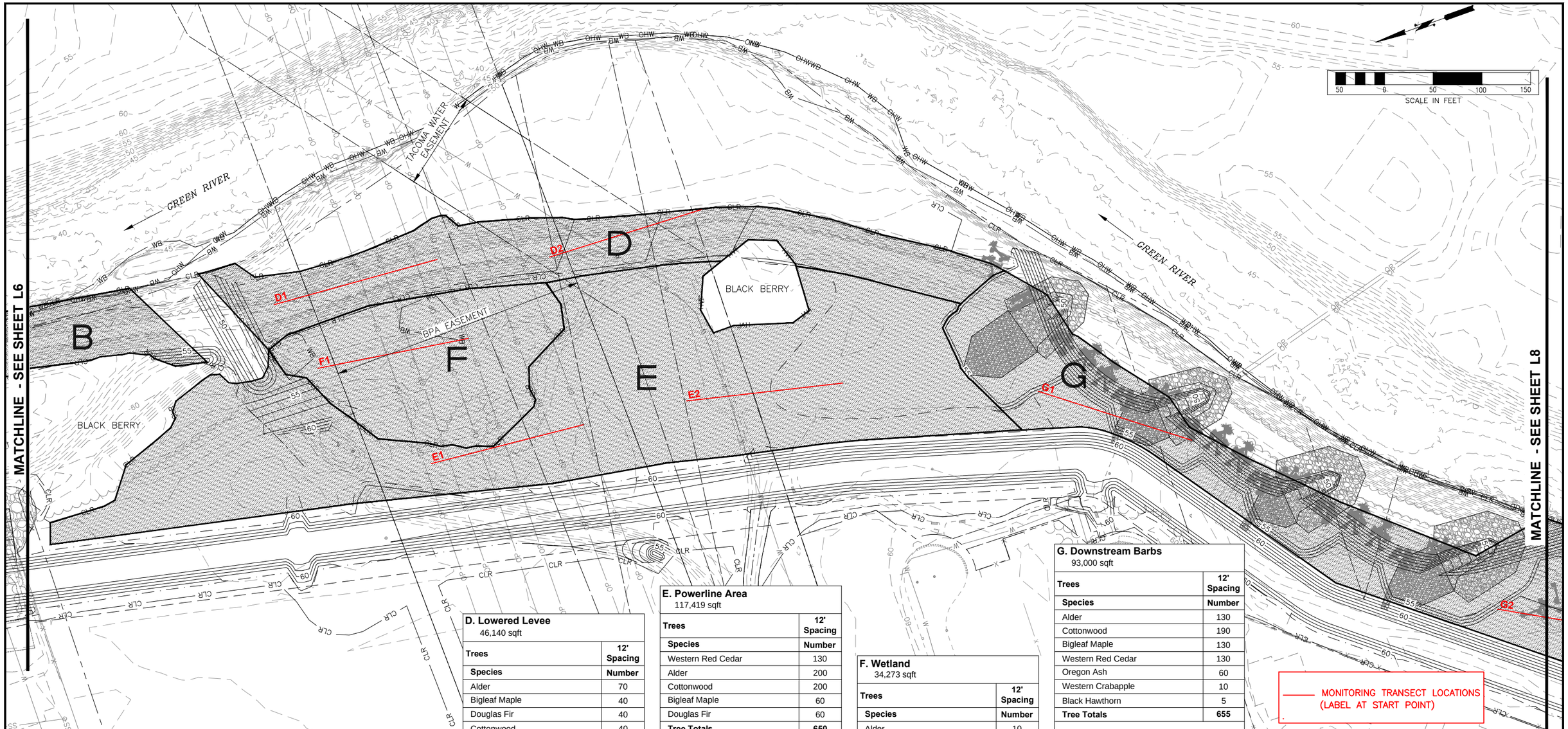
PLANTING PLAN - NOVEMBER 2013 REVISION

SHEET L6 OF 107 SHEETS



NOTES:

1. WILLOW STAKES 1–2 INCHES DIAMETER BY 6 FEET LONG.
2. * PLANT ONLY SHRUBS UNDER POWER LINE ROW. ALL VINE MAPLE FOR AREAS "D", "E", AND "F" GO UNDER POWER LINES, AVERAGE SPACING OF SHRUBS AND VINE MAPLE UNDER POWER LINES TO BE 6 FEET.
3. START PLANTING AREAS "G" AND "H" 6 FEET VERTICAL BELOW TOP OF LEVEE.
4. WILLOW AND OREGON ASH IN PLANTING AREAS "G" WILL BE USED PRIMARILY BETWEEN BARBS.
5. PLANTING AREA "G" MAY BE PLANTED AFTER FIRST SIGNIFICANT HIGH FLOWS.

D. Lowered Levee
46,140 sqft

Trees	12' Spacing
Species	**Number**
Alder	70
Bigleaf Maple	40
Douglas Fir	40
Cottonwood	40
Tree Totals	**190**
Shrubs	**7' Spacing***
Species	**Number**
Red Twig Dogwood	370
Snowberry	230
Black Twinberry	140
Thimbleberry	90
Baldhip Rose	90
Ocean Spray	20
Vine Maple	120
Shrub Totals	**1,060**

E. Powerline Area
117,419 sqft

Trees	12' Spacing
Species	**Number**
Western Red Cedar	130
Alder	200
Cottonwood	200
Bigleaf Maple	60
Douglas Fir	60
Tree Totals	**650**
Shrubs	**7' Spacing***
Species	**Number**
Red Twig Dogwood	800
Snowberry	360
Black Twinberry	360
Thimbleberry	240
Cluster Rose	190
Mock Orange	50
Tall Oregon Grape	200
Vine Maple	370
Shrub Totals	**2,570**

F. Wetland
34,273 sqft

Trees	12' Spacing
Species	**Number**
Alder	10
Western Red Cedar	10
Tree Totals	**20**
Shrubs	**7' Spacing***
Species	**Number**
Red Twig Dogwood	250
Snowberry	100
Black Twinberry	180
Thimbleberry	200
Cluster Rose	170
Vine Maple	40
Shrub Totals	**940**

G. Downstream Barbs
93,000 sqft

Trees	12' Spacing	
Species	**Number**	
Alder	130	
Cottonwood	190	
Bigleaf Maple	130	
Western Red Cedar	130	
Oregon Ash	60	
Western Crabapple	10	
Black Hawthorn	5	
Tree Totals	**655**	
Shrubs	**7' Spacing***	
Species	**Number**	
Red Twig Dogwood	280	
Snowberry	660	
Black Twinberry	100	
Thimbleberry	170	
Baldhip Rose	~~190~~	90
Cluster Rose	~~100~~	66
Mock Orange	50	
Tall Oragon Grape	50	
Willow Stakes	300	
Shrub Totals	**~~1,900~~**	1,766

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REVIEWED:	LISA BRANDT	11/20/2013
CAD DESIGN:	KAY KITAMURA	11/20/2013

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River and Floodplain Management Section
Christie True, Director

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PLANTING PLAN - NOVEMBER 2013 REVISION

SHEET L7 OF 107 SHEETS

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——— MONITORING TRANSECT LOCATIONS (LABEL AT START POINT)

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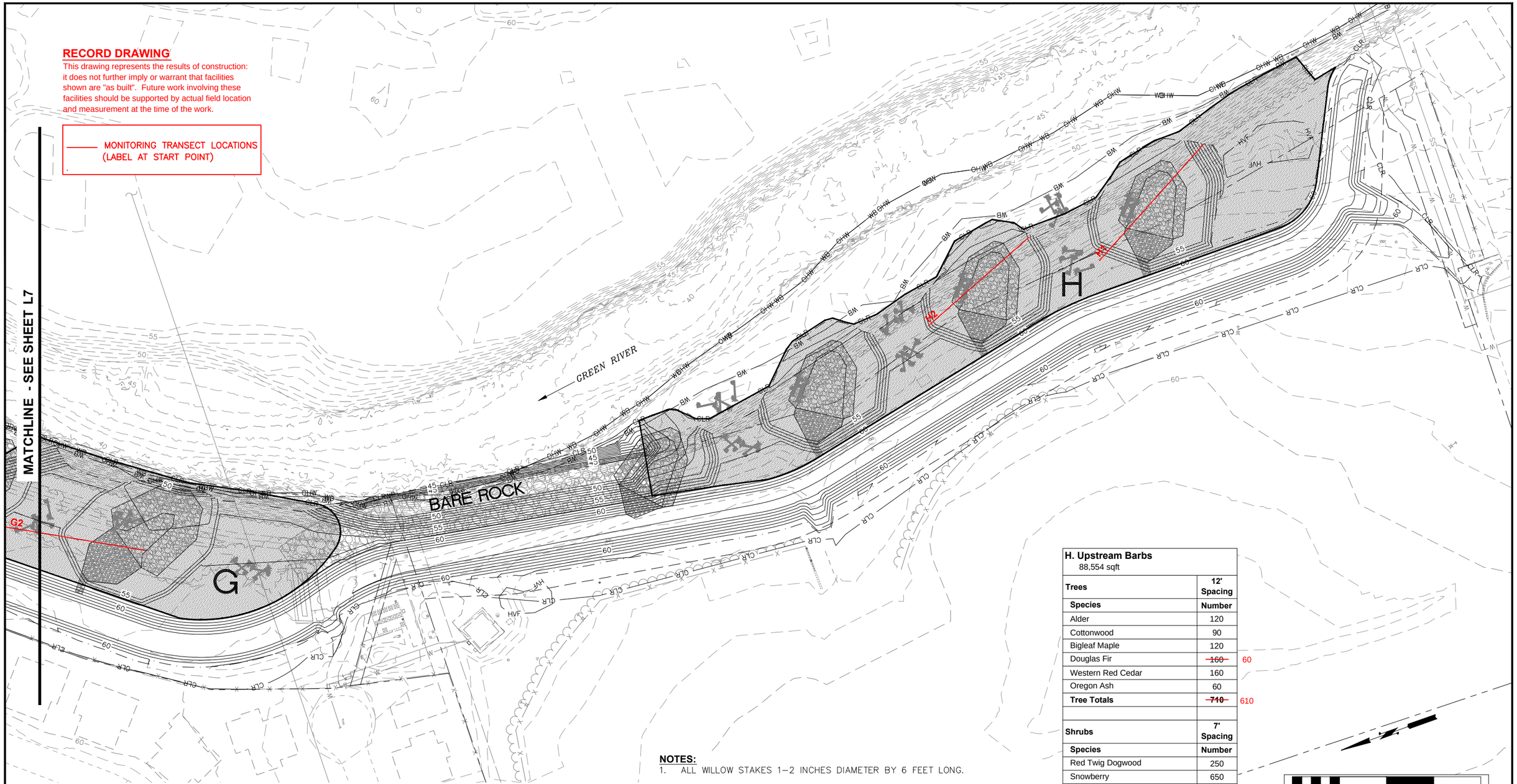

NOTES:

1. ALL WILLOW STAKES 1–2 INCHES DIAMETER BY 6 FEET LONG.
2. START PLANTING AREAS "G" AND "H" 6 FEET VERTICAL BELOW TOP OF LEVEE.
3. WILLOW AND OREGON ASH IN PLANTING AREAS "G" WILL BE USED PRIMARILY BETWEEN BARBS.
4. PLANTING AREA "G" MAY BE PLANTED AFTER FIRST SIGNIFICANT HIGH FLOWS.

H. Upstream Barbs 88,554 sqft		
Trees	**12' Spacing**	
Species	**Number**	
Alder	120	
Cottonwood	90	
Bigleaf Maple	120	
Douglas Fir	~~160~~	60
Western Red Cedar	160	
Oregon Ash	60	
Tree Totals	~~710~~	610
Shrubs	**7' Spacing**	
Species	**Number**	
Red Twig Dogwood	250	
Snowberry	650	
Black Twinberry	100	
Thimbleberry	350	
Baldhip Rose	200	
Mock Orange	30	
Tall Oregon Grape	80	
Ocean Spray	150	
Shrub Totals	**1,810**	

50 0 50 100 150
SCALE IN FEET

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PLANTING PLAN - NOVEMBER 2013 REVISION

SHEET L8 OF 107 SHEETS

RECORD DRAWING

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NOTES:

1. PLANT ASH LOWEST ON SLOPE, ALDER MID-SLOPE, AND FIR AND MAPLE MID-TO UPPER-SLOPE.

I. Auburn Golf Revetment 46,069 sqft	
Trees	**10' Spacing**
Species	**Number**
Alder	120
Ash	110
Douglas Fir	120
Bigleaf Maple	~~110~~ 168
Tree Totals	~~460~~ 518
Shrubs	**6' Spacing**
Species	**Number**
Willow Stakes	75
Shrub Totals	**75**

50 0 50 100 150
SCALE IN FEET

GREEN RIVER

MATCHLINE - SEE SHEET L10

CALL 2 WORKING DAYS
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1-800-424-5555
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REDDINGTON LEVEE SETBACK

RIGHT BANK SUPPLEMENTAL PLANTING PLAN
NOVEMBER 2013 REVISION

SHEET L9 OF 107 SHEETS

RECORD DRAWING
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NOTES:
1. PLANT ASH LOWEST ON SLOPE, ALDER MID-SLOPE, AND FIR AND MAPLE MID-TO UPPER-SLOPE.
2. PLANT ONLY WILLOWS UNDER BPA EASEMENT IN SECTION "I", NO TREES.
   DO NOT PLANT PACIFIC WILLOW.

I. Auburn Golf Revetment
46,069 sqft

Trees	10' Spacing	
Species	**Number**	
Alder	120	
Ash	110	
Douglas Fir	120	
Bigleaf Maple	~~110~~	168
Tree Totals	~~460~~	518
Shrubs	**6' Spacing**	
Species	**Number**	
Willow Stakes	75	
Shrub Totals	**75**	

J. Isaac Evans Main Planting
101,107 sqft

Trees	22' Spacing
Species	**Number**
Ash	10
Alder	10
Western Red Cedar	80
Bigleaf Maple	20
Douglas Fir	90
Tree Totals	**210**

50 0 50 100 150
SCALE IN FEET

CALL 2 WORKING DAYS
BEFORE YOU DIG
1-800-424-5555
(UNDERGROUND UTILITY LOCATIONS ARE APPROX.)

MATCHLINE - SEE SHEET L9
MATCHLINE - SEE SHEET L11

BPA EASEMENT
GREEN RIVER
GREEN RIVER
I
J
L7

NUM.	REVISION	BY	DATE
R1	RECORD CHANGES	S.M.	12-8-2014
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RIGHT BANK SUPPLEMENTAL PLANTING PLAN
NOVEMBER 2013 REVISION

SHEET L10 OF 107 SHEETS

RECORD DRAWING

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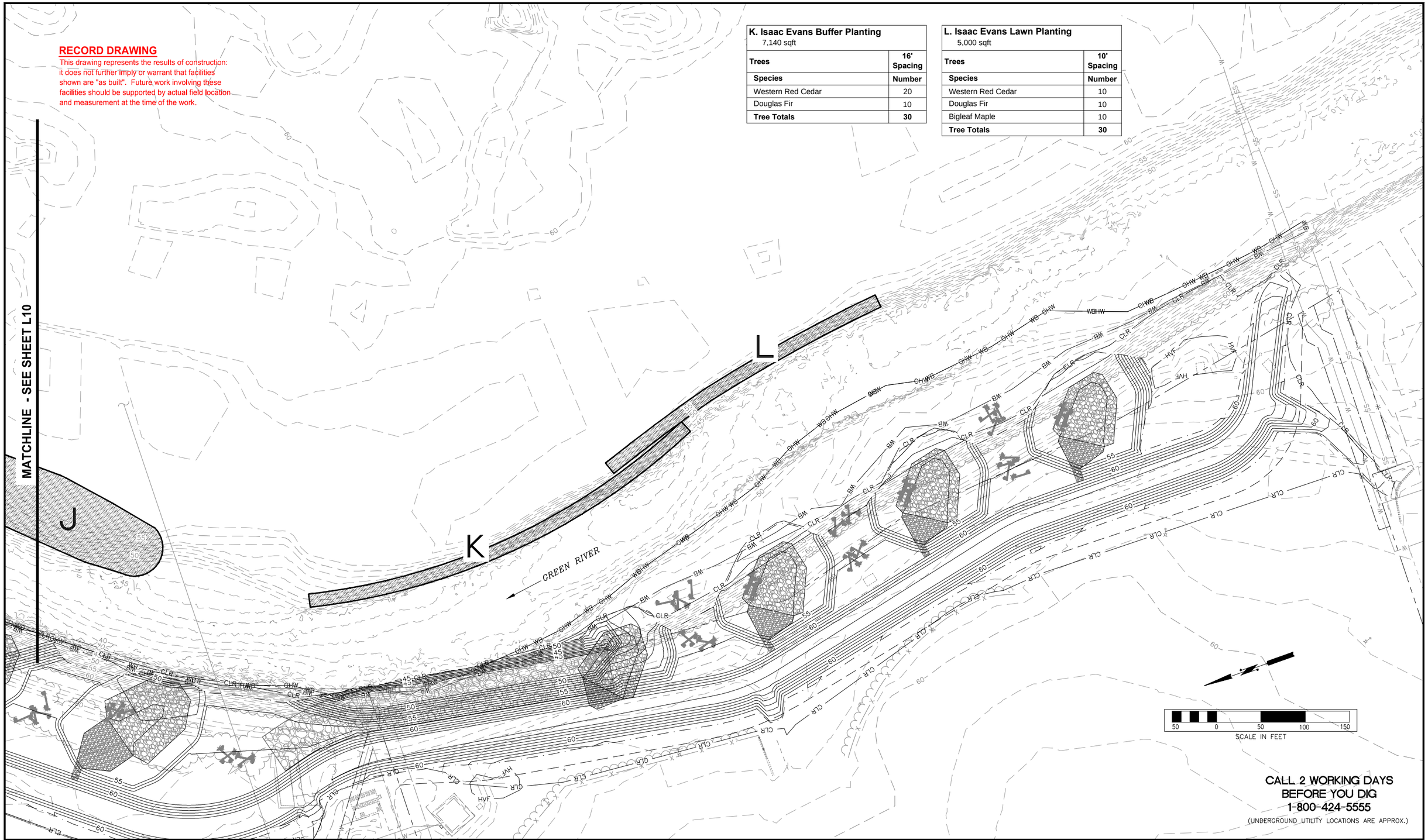
K. Isaac Evans Buffer Planting
7,140 sqft

Trees	16' Spacing
Species	**Number**
Western Red Cedar	20
Douglas Fir	10
Tree Totals	**30**

L. Isaac Evans Lawn Planting
5,000 sqft

Trees	10' Spacing
Species	**Number**
Western Red Cedar	10
Douglas Fir	10
Bigleaf Maple	10
Tree Totals	**30**



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REDDINGTON LEVEE SETBACK

RIGHT BANK SUPPLEMENTAL PLANTING PLAN
NOVEMBER 2013 REVISION

SHEET L11 OF 107 SHEETS

Appendix B – Photos from plant monitoring transects

Transect A1 Start, 09/12/2014

Transect A1 End, 9/12/2014

Transect A2 Start, 09/12/2014

Transect A2 End, 9/12/2014

Transect A3 Start, 09/12/2014

Transect A3 End, 9/12/2014

Transect C1 Start, 09/12/2014

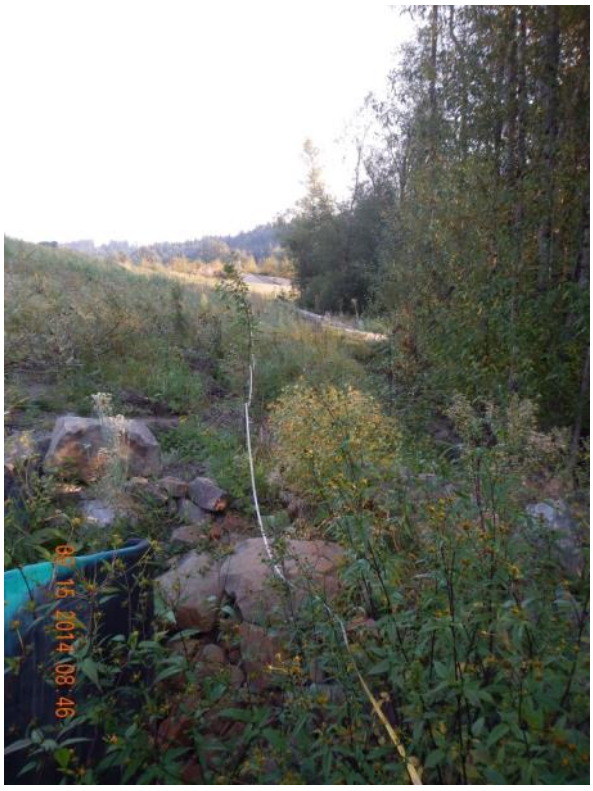
Transect C1 End, 9/12/2014

Transect C2 Start, 09/12/2014

(photo not available)

Transect C2 End, 9/12/2014

Transect C3 Start, 09/15/2014



Transect C3 End, 9/15/2014

Transect D1 Start, 09/12/2014

Transect D1 End, 9/12/2014

Transect D2 Start, 9/12/2014

Transect D2 End, 9/12/2014

Transect E1 Start, 09/15/2014

Transect E1 End, 9/15/2014

Transect E2 Start, 09/15/2014

Transect E2 End, 9/15/2014

Transect F1 Start, 09/15/2014

Transect F1 End, 9/15/2014

Transect G1 Start, 09/15/2014

Transect G1 End, 9/15/2014

Transect G2 Start, 09/15/2014

Transect G2 End, 9/15/2014

Transect H1 Start, 09/09/2014

Transect H1 End, 9/09/2014

Transect H2 Start, 09/09/2014

Transect H2 End, 9/09/2014